Technische Universität Braunschweig

Institut für mobile Maschinen und Nutzfahrzeuge

Efficiency of Mobile Machines and their Applications

A Contribution to the Reduction of GHG

Symposium 10th / 11th March 2015 in Braunschweig

Flyer of the Symposium (1)

Technische Universität Braunschweig

Institut für mobile Maschinen und Nutzfahrzeuge

Programme committee

- **Ulrich Adam** – CEMA, Brüssel
- **August Altherr** – John Deere, Kaiserslautern
- **Belén Bravo** – CECE, Brüssel
- **Reiner Brunsch** – Institute for Agricultural Engineering, Potsdam-Bornim
- **Wolfgang Burget** – Liebherr, Kirchdorf
- **Ludger Frerichs** – Institute of Mobile Machines and Commercial Vehicles, Braunschweig
- **Marcus Geimer** – Institute of Vehicle System Technology, Karlsruhe
- **Günter Hähn** – Wirtgen, Windhagen
- **Eberhard Nacke** – CLAAS, Harsewinkel
- **David Tinker** – EurAgEng, Bedford

Organizer

Scientific lead: Institute of Mobile Machines and Commercial Vehicles

Organisation: ITS Niedersachsen

Conference fees

Participant: 290€ + VAT

Student: Please contact the conference administration

Conference fees include the proceedings, catering during the conference and the evening reception.

Registration

Please visit our website:

www.tu-braunschweig.de/imn/emma

Hotel

List of hotels for the conference participants, please look at the website.

Venue

ZUCKER – Restaurant in der Raffinerie
Frankfurter Str. 2
38122 Braunschweig

Stadthalle Braunschweig Congress Hall
Leonhardtplatz 1
38102 Braunschweig

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Website: www.tu-braunschweig.de/imn/emma

ITS Niedersachsen

Efficiency of Mobile Machines and their Applications

A Contribution to the Reduction of GHG

Symposium at the Institute of Mobile Machines and Commercial Vehicles

10th/ 11th March 2015, Braunschweig

Flyer of the Symposium (2)

Introduction

The latest EU climate targets for the year 2030, 40 % reduction of CO_2 emissions relating to 1990, might be achievable but only under great efforts of all those involved. Manufacturers of mobile machines want to and must make their contribution. But the market of mobile machines is characterized by a wide diversity and the application on construction, agriculture and municipal sites etc. varies even more. Against this background the Braunschweig Symposium in March 2015 aims to establish a forum for an international and all-sector exchange about efforts and opportunities to increase efficiency of machines and processes. The Symposium will point out in particular the role of the agricultural and construction machinery in context of the EU climate targets, what measures will contribute to a reduction of CO_2 emissions and how this may be evidenced. Intelligent solutions for the technology as well as for any regulatory demands are required due to the diversity and complexity. Since single CO_2 limits are not reasonable, the manufacturers are going to prepare solutions for a voluntary commitment. First conceptual solutions are elaborated for this purpose and will be presented at the Symposium.

The international Symposium „Efficiency of Mobile Machines and their Applications“ will offer the chance to discuss demands and approaches for one of the most significant future topics. Increasing efficiency means to improve the productivity, the consumption of resources as well as the emission of greenhouse gases. Hence this is the key for smart handling of regulatory demands, for improving the public acceptance of manufacturers and users and not at least for business success.

Welcome to Braunschweig, have a successful Symposium.

Prof. Dr. Ludger Frerichs

Programme

Tuesday, 10th March 2015
Venue: ZUCKER – Restaurant in der Raffinerie

18:00 **Evening reception**
Dinner speech
Improvement in efficiency of thinking processes
Prof. Martin Korte (TU Braunschweig)
Dinner

Wednesday, 11th March 2015
Venue: Stadthalle Braunschweig – Congress Hall

Session I: Background to the topic (Ludger Frerichs)

08:30 **Opening remarks**
Prof. Ludger Frerichs (TU Braunschweig)

08:45 **The global context of GHG-emissions and climate change**
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Dr. Peter Krammer (STRABAG)

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Dr. Martin Göbel (Wirtgen GmbH)

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11:45 **Efficiency potentials of ICT in agriculture**
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(Maschinenfabrik Bernard Krone GmbH)

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13:15 **Sustainable energy storages for mobile machines**
Prof. Marcus Geimer (Karlsruhe Inst. of Technology)

13:45 **What prevents us from using more efficient technology?**
Prof. Reiner Brunsch (ATB Potsdam)

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14:30 **CO_2-quantification of agricultural machinery**
M.Sc. Beate Fleck (CLAAS KGaA mbH),
M.Sc. Steffen Hanke (TU Braunschweig)

15:00 **CO_2-quantification of mobile machines on construction sites**
Dipl.-Ing. Isabelle Ays (Karlsruhe Inst. of Technology)

15:30 **We need smart regulation for mobile machines**
Dr. Ulrich Adam (CEMA Brussels)

16:00 **Discussion**
Prof. Ludger Frerichs (TU Braunschweig)

16:30 **Coffee to go**

Supported by

CLAAS · LIEBHERR · JOHN DEERE · Wirtgen

Persons involved

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Conference Director

Ludger Frerichs, TU Braunschweig

Editor

Steffen Hanke, TU Braunschweig

Wednesday, 11th March 2015 (1)

Venue: Stadthalle Braunschweig – Congress Hall

Wednesday, 11th March 2015 (2)

Venue: Stadthalle Braunschweig – Congress Hall

Technische Universität Braunschweig

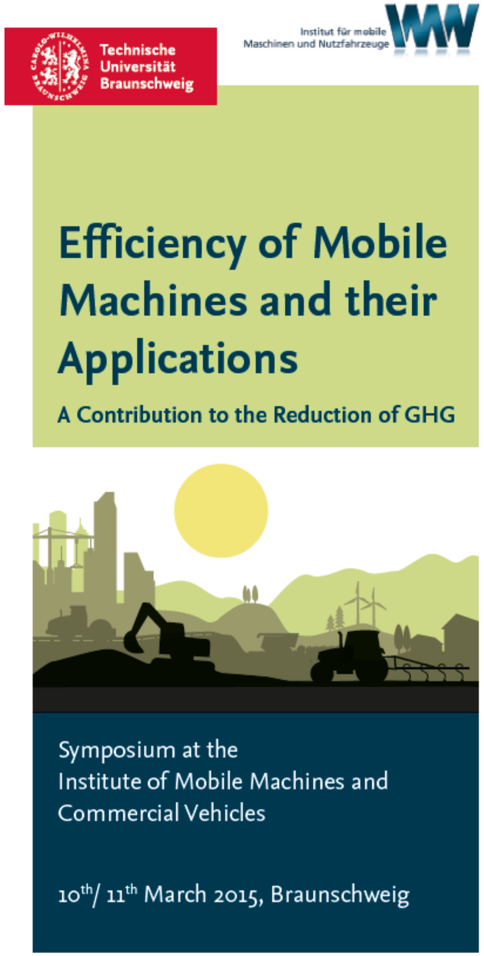
Institut für mobile Maschinen und Nutzfahrzeuge

Efficiency of Mobile Machines and their Applications

A Contribution to the Reduction of GHG

Symposium 10th / 11th March 2015 in Braunschweig

Welcome

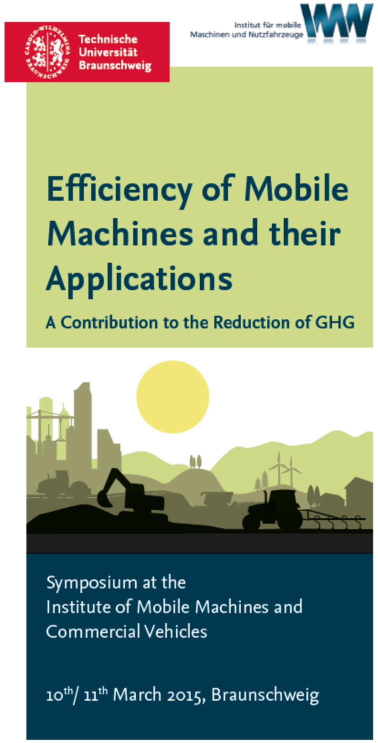


Welcome to all our guests!

A special welcome and many thanks to the

- **authors and co-authors**
- **section chairs**
- **press representatives**

… and many thanks for your support



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Wolfgang Burget	Liebherr
Günter Hähn	Wirtgen
Eberhard Nacke	CLAAS
Reiner Brunsch	ATB
Ludger Frerichs	IMN
Marcus Geimer	MOBIMA
Ulrich Adam	CEMA
Belén Bravo	CECE
David Tinker	EurAgEng

Operational:

Steffen Hanke	IMN
Andreas Redeker	ITS Niedersachsen

Sponsors:

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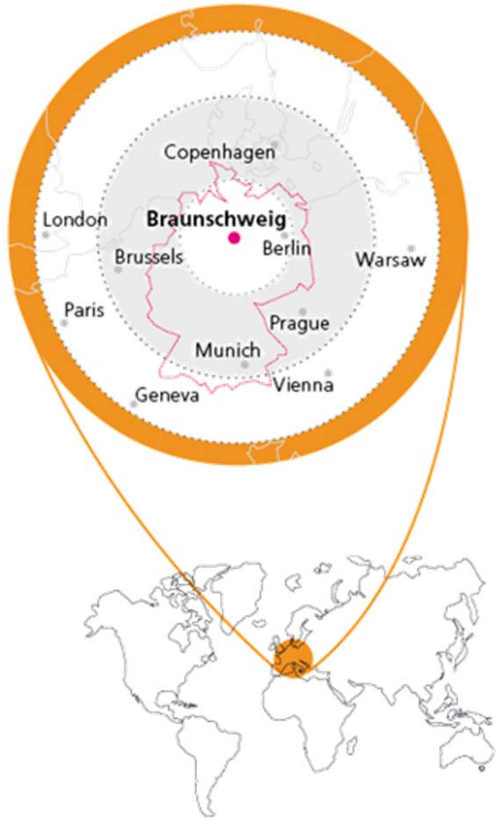
Welcome to Braunschweig / Brunswick

Europe's Number 1 Research Region

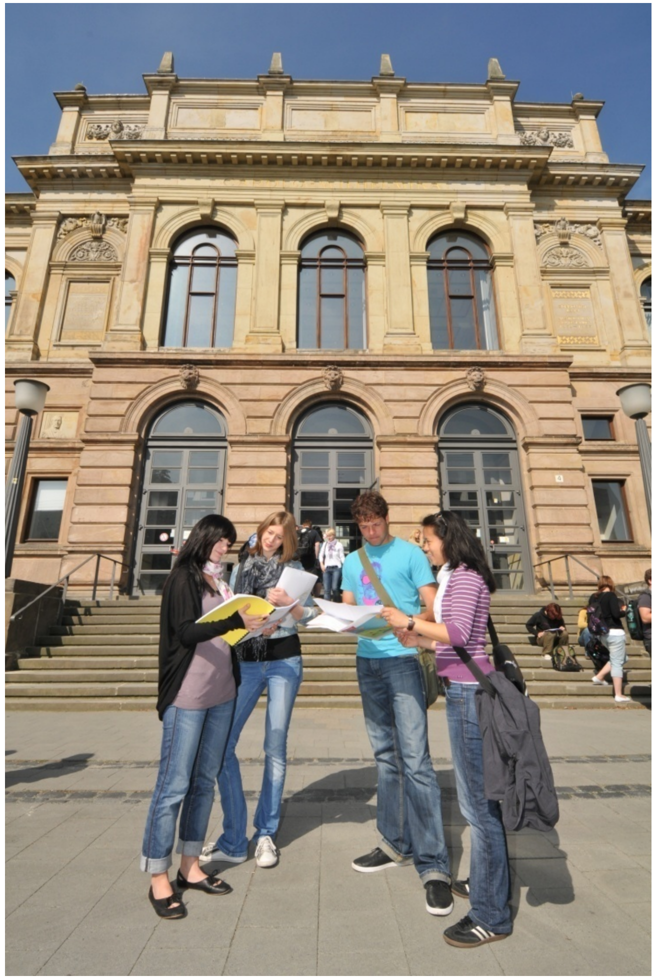
FORSCHUNGREGION BRAUNSCHWEIG

- **4 Higher education institutions**
- **18 Non-academic research institutes**
- **More than 50 companies with research departments**
- **Region with the highest level of research and development expenditures in Europe** (Eurostat)
- **Ranked first in the nation for the number of inhabitants working in science** (Zukunftsatlas)



Technische Universität Braunschweig

6	Departments
71	Degree programmes
120	Institutes
2,089	Scientists
4,730	First semester students (each year)
18,474	Students



6 Departments

1. Carl-Friedrich Gauß:
   Mathematics, Computer Science,
   Business Science and Social Sciences

2. Life Sciences

3. Architecture, Civil Engineering and
   Environmental Sciences

4. Mechanical Engineering

5. Electrical Engineering, Information
   Technology and Physics

6. Humanities and Educational Sciences

Carolo-Wilhelmina Research Centres

Mobility

- **Automotive Research Centre Lower Saxony**
- Aeronautics Research Centre Lower Saxony (NFL)

Infections and Active Agents

- Braunschweig Integrated Centre of Systems Biology (BRICS)
- Centre for Pharmaceutical Process Engineering (PVZ)

Nanometrolgy

- Laboratory for Emerging Nanometrology and Analytics (LENA)

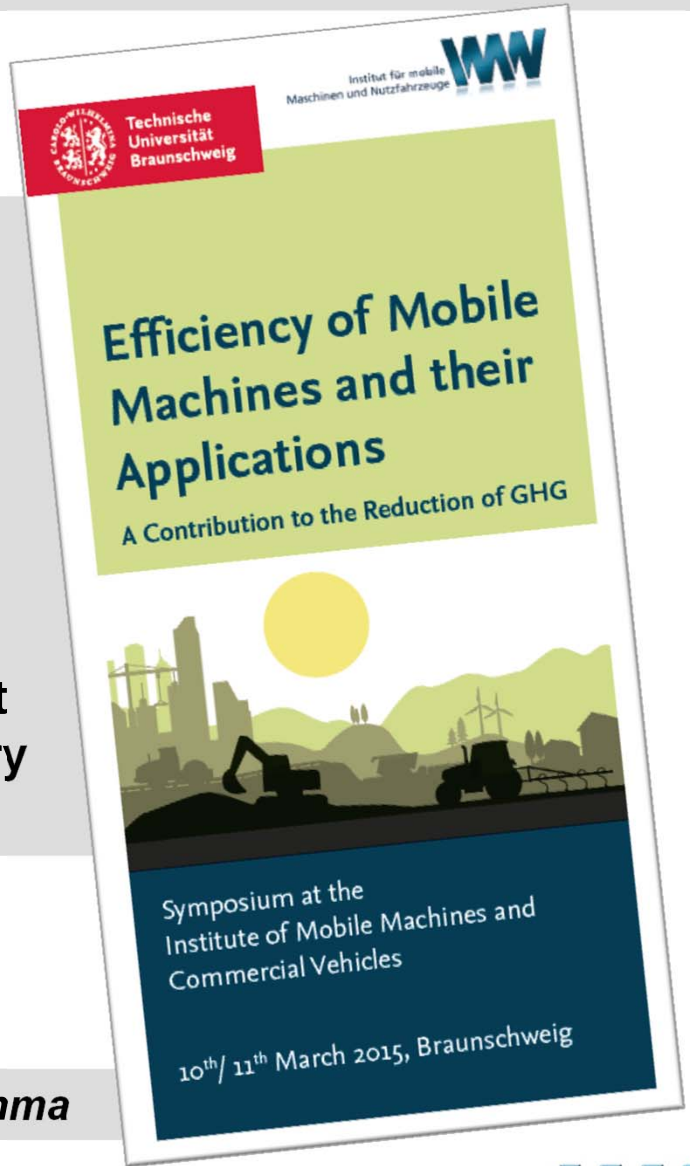
February 2015

The Symposium

- **Forum for an international and all-sector exchange on one of the most significant future topics: Efficiency**

- **What measures will contribute to a reduction of CO_2 emissions and how this can be evidenced**

- **Suggest a voluntary commitment concept of construction and agricultural machinery industry on CO_2 reduction**



Proceedings: www.tu-braunschweig.de/imn/emma

Wording and Definitions

Efficiency

Is the relation of result and applied means (EN ISO 9000)
(doing things right)

Also in the meaning of Efficiency used:

Intensity

eg. invested energy to gain a production unit

Productivity

eg. production units per invested energy unit

…

do not take **Effectivity** into account

Effectivity

Represents the value or the quality of the achieved objectives

(doing the right things)

The Success of Efficiency Depends on the Effectivity

	Effective	Ineffective
Efficient	++	-
Inefficient	o	--

Qualified Efficiency

Efficiency

Output/Input oriented

Effectivity

Output oriented
(Quality, …)

Qualified Efficiency

Relation of result and applied means taking into account output quality

Sustainable Efficiency Improvement

How to rise Efficiency and

how to utilize the Efficiency Profit:

$$\eta = \frac{\text{Result}}{\text{Applied Means}}$$

- **Maximisation principle**

  Increasing result - applied means constant

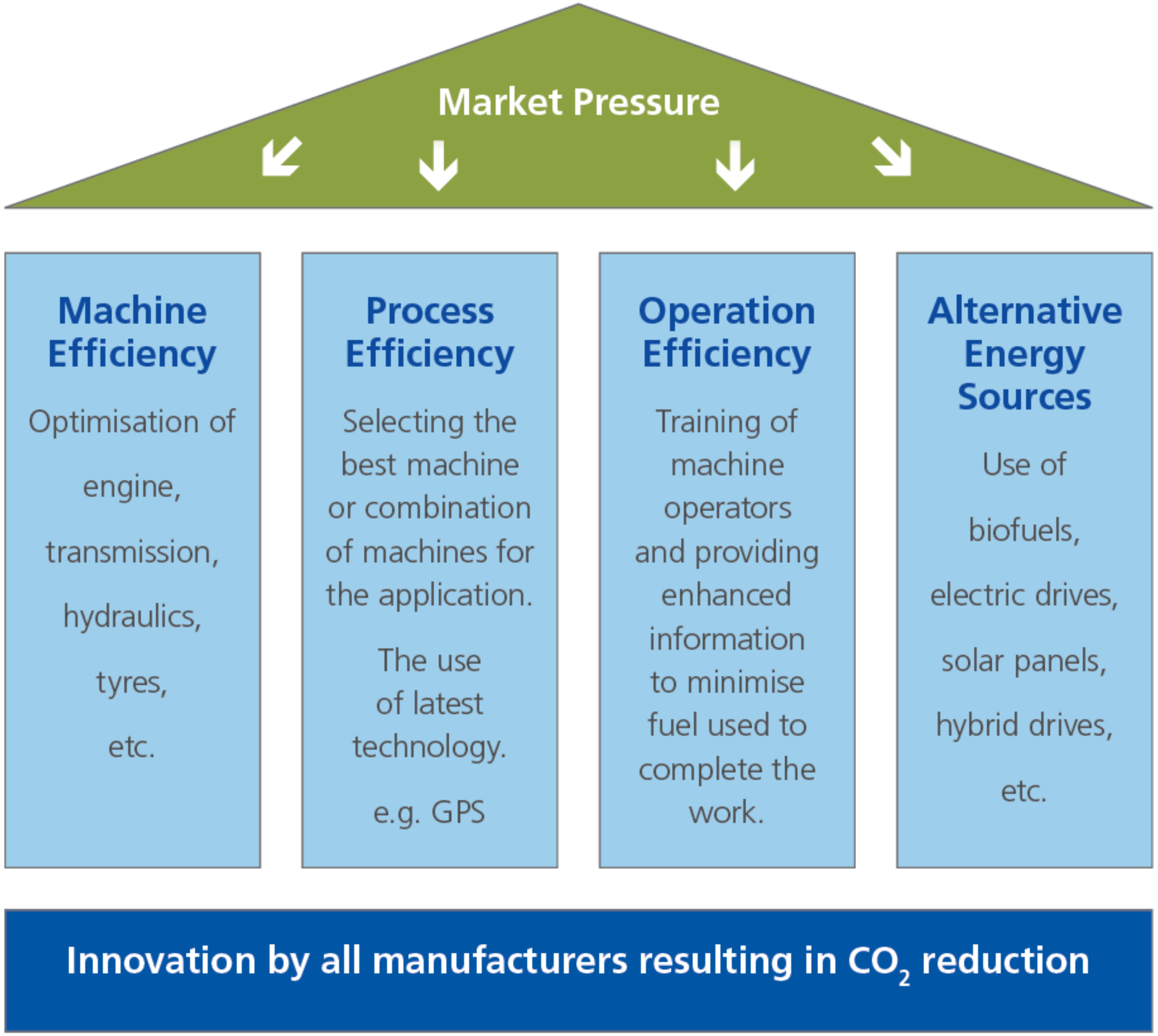
- **Minimisation principle:**

  Keep result - minimise applied means

Success factor of sustainable production is
the smart utilisation of the Efficiency Profit.

Hence, Efficiency improvement is only sustainable
when taking Effectivity account and doing the right things!

Doing the Right Things for “Sustainable Production”



[CECE/CEMA}

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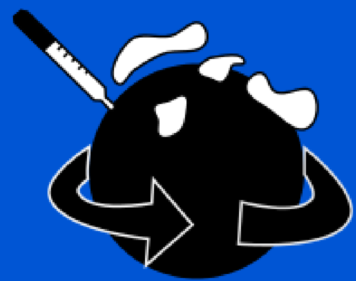
The global context of climate change and greenhouse gas emissions

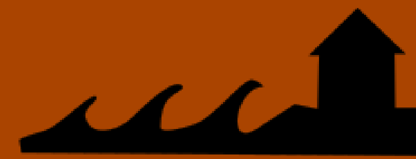
Dr. Benjamin Leon Bodirsky

POTSDAM-INSTITUT FÜR KLIMAFOLGENFORSCHUNG

CSIRO

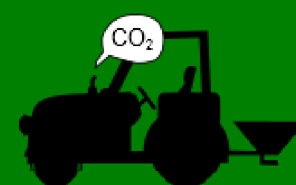


Climate Change



Impacts

Emissions



Mitigation

Conclusions


Climate Change

Figure SPM.1a

Observed globally averaged combined land and ocean surface temperature anomaly 1850-2012

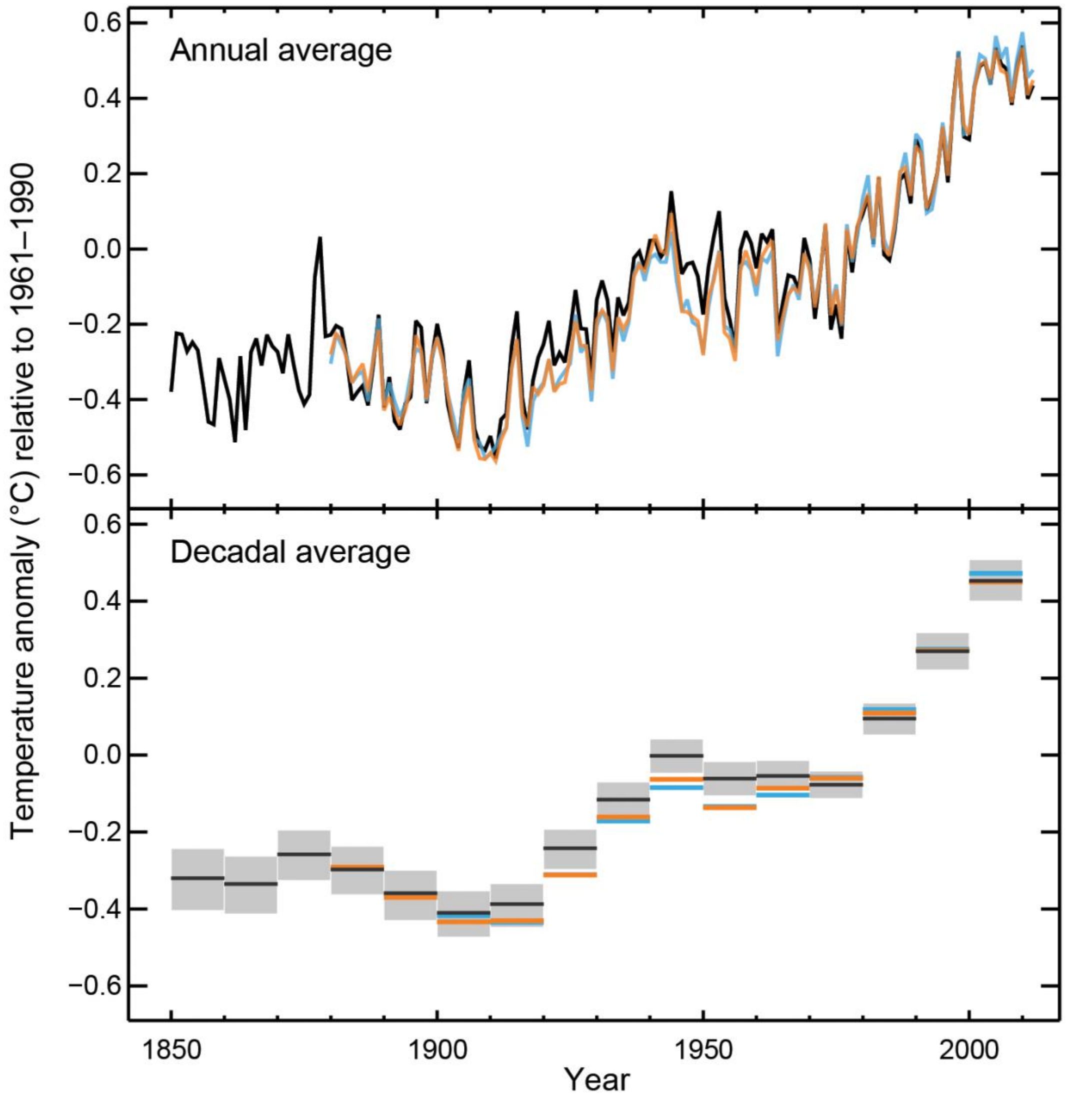


Figure SPM.1b

Observed change in surface temperature 1901-2012

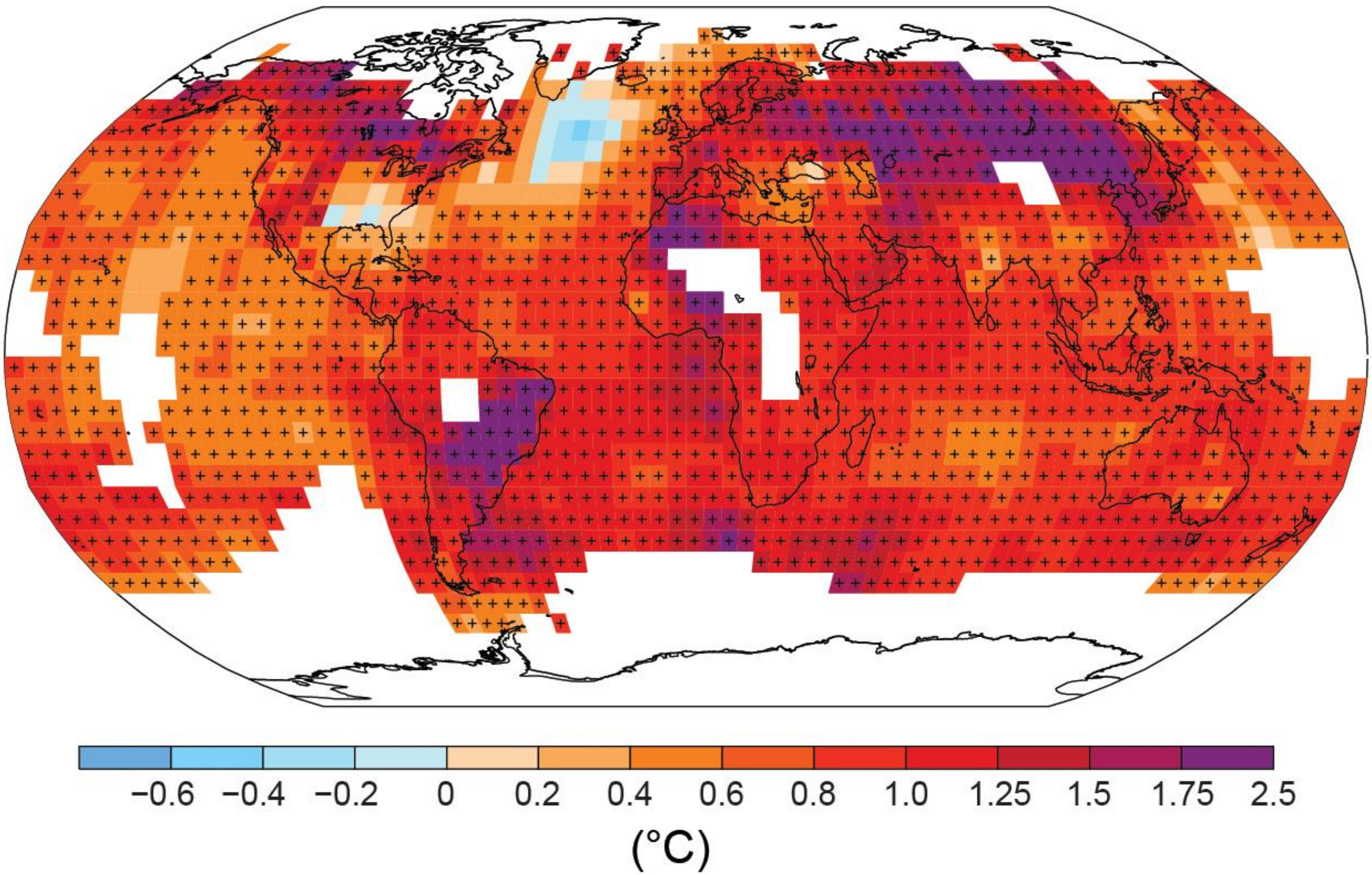


Figure SPM.2

Observed change in annual precipitation over land

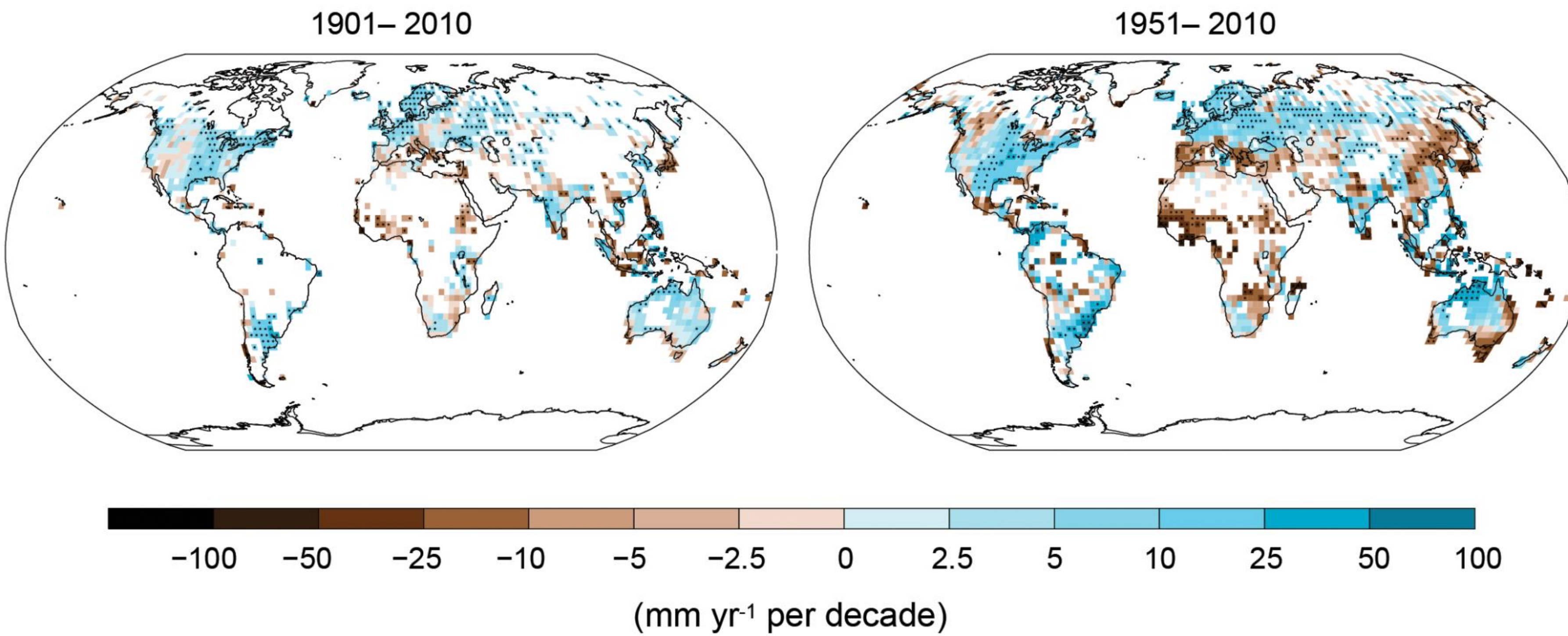
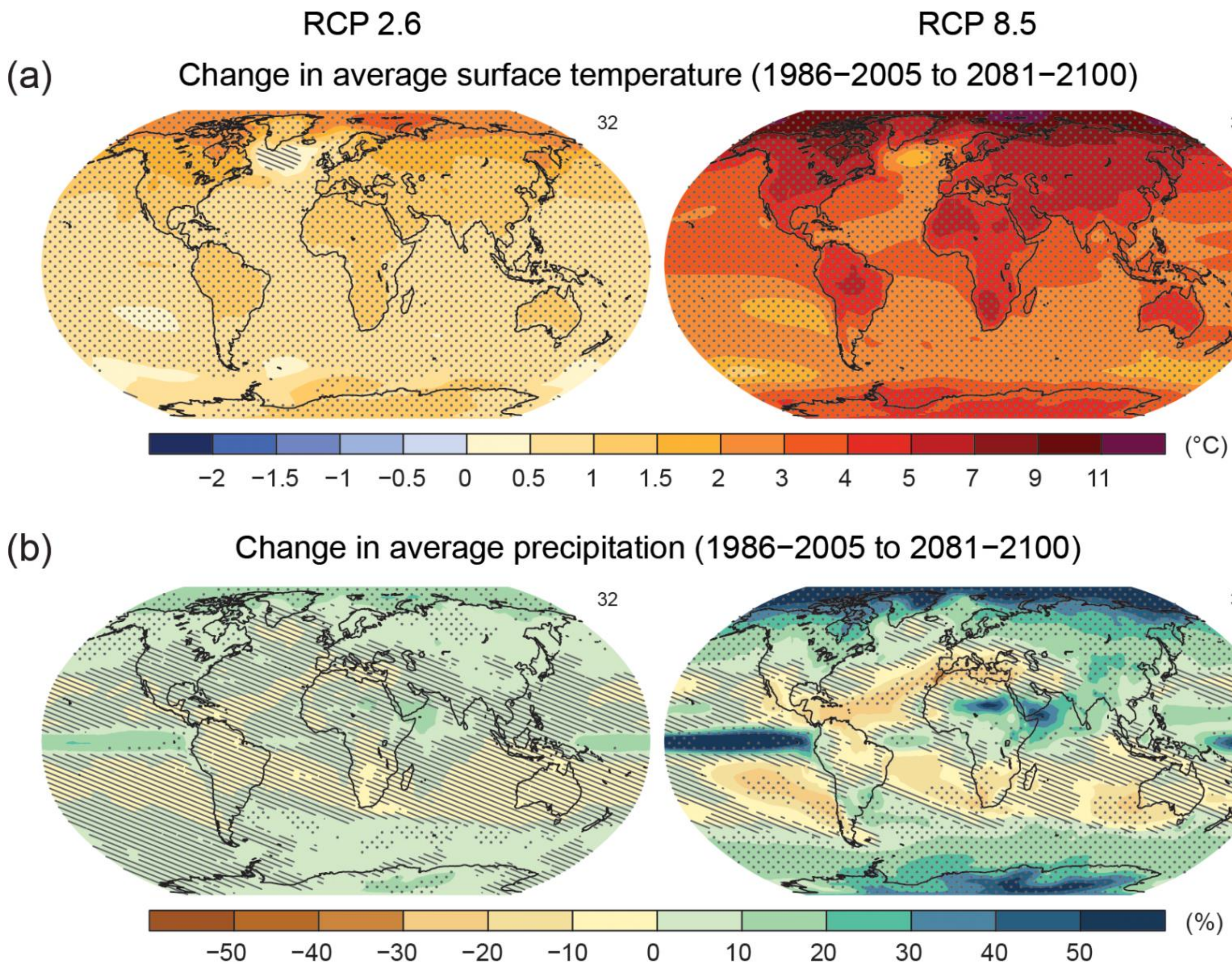


Figure SPM.8a,b

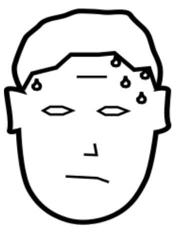
Maps of CMIP5 multi-model mean results




Impacts

Glacier melting

Coral reef
bleeching

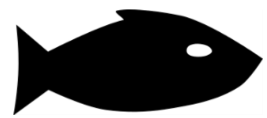


Heat waves

Draughts

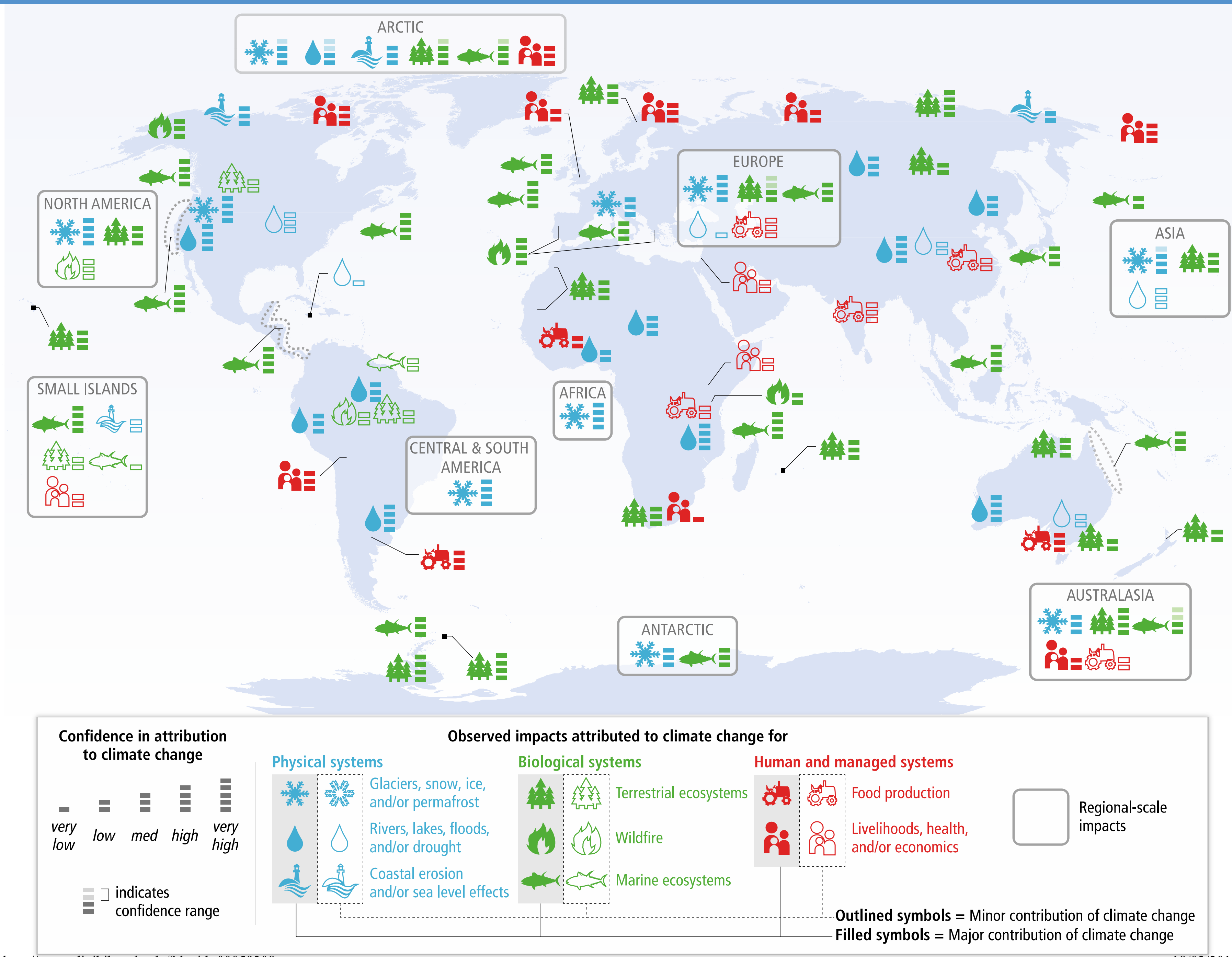
Amazon forest
becoming savannah

Sea level rise,
floods



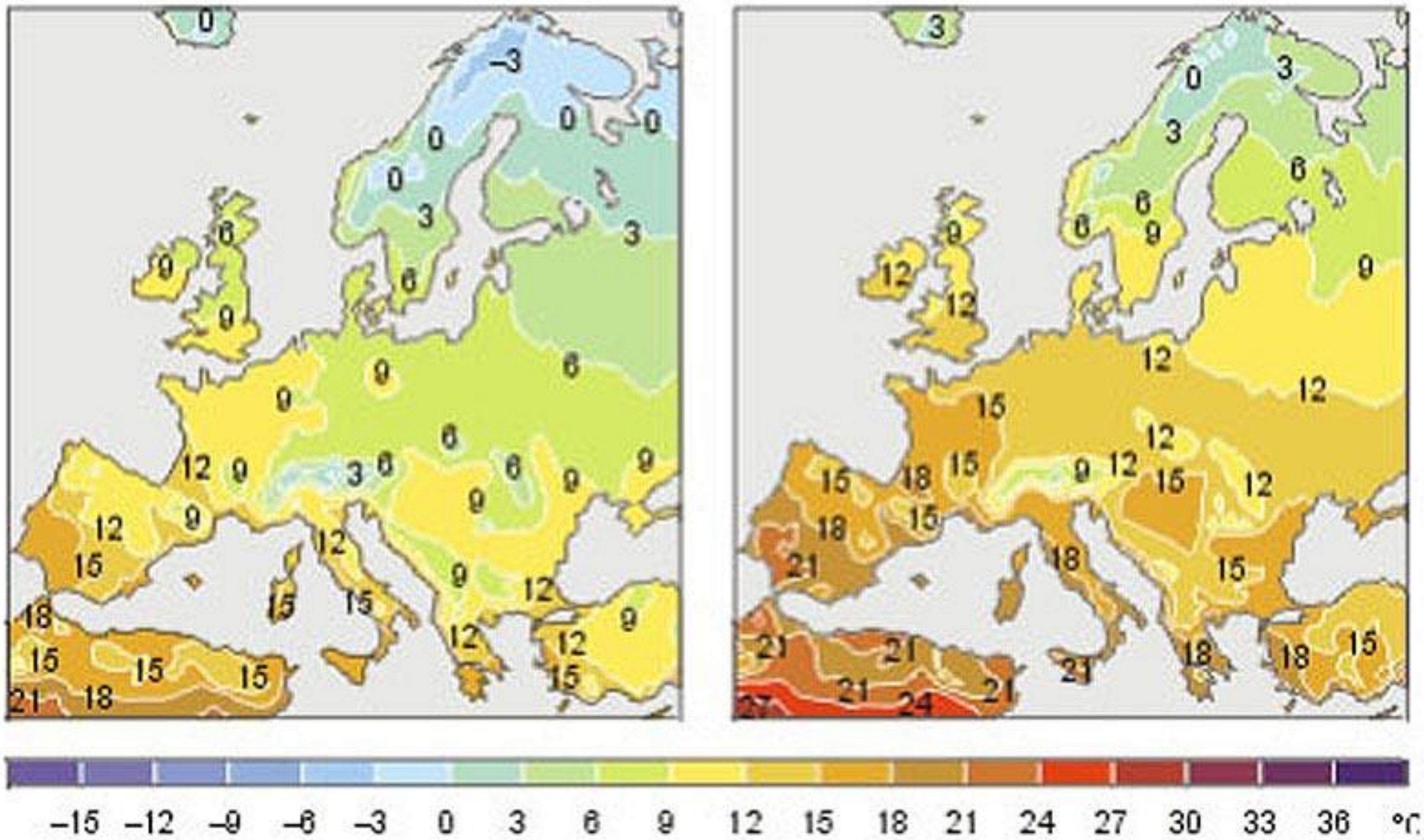
Reduced fish
catches

...



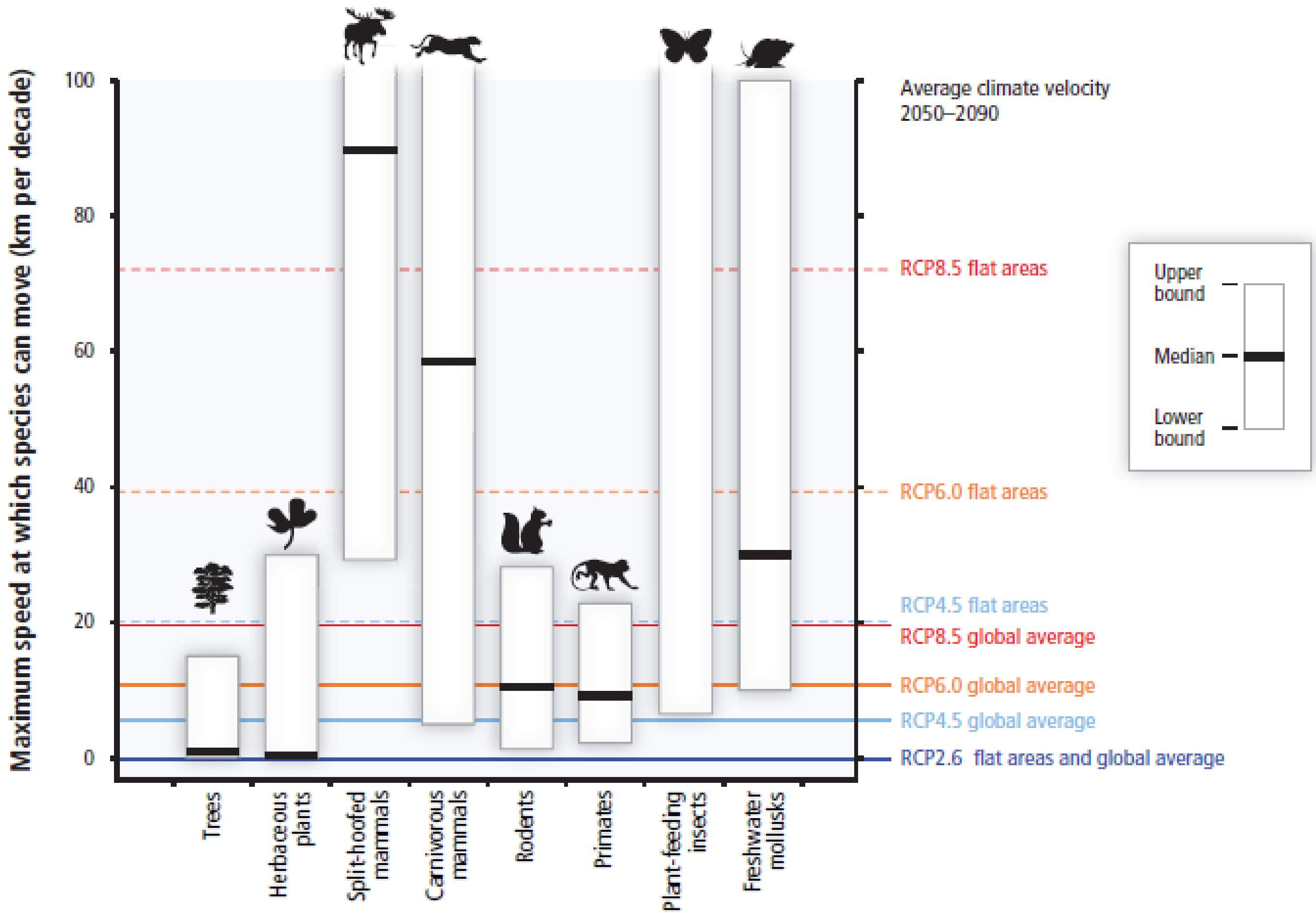
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
AUSTRALASIA
ANTARCTIC
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

Do 4°C matter?

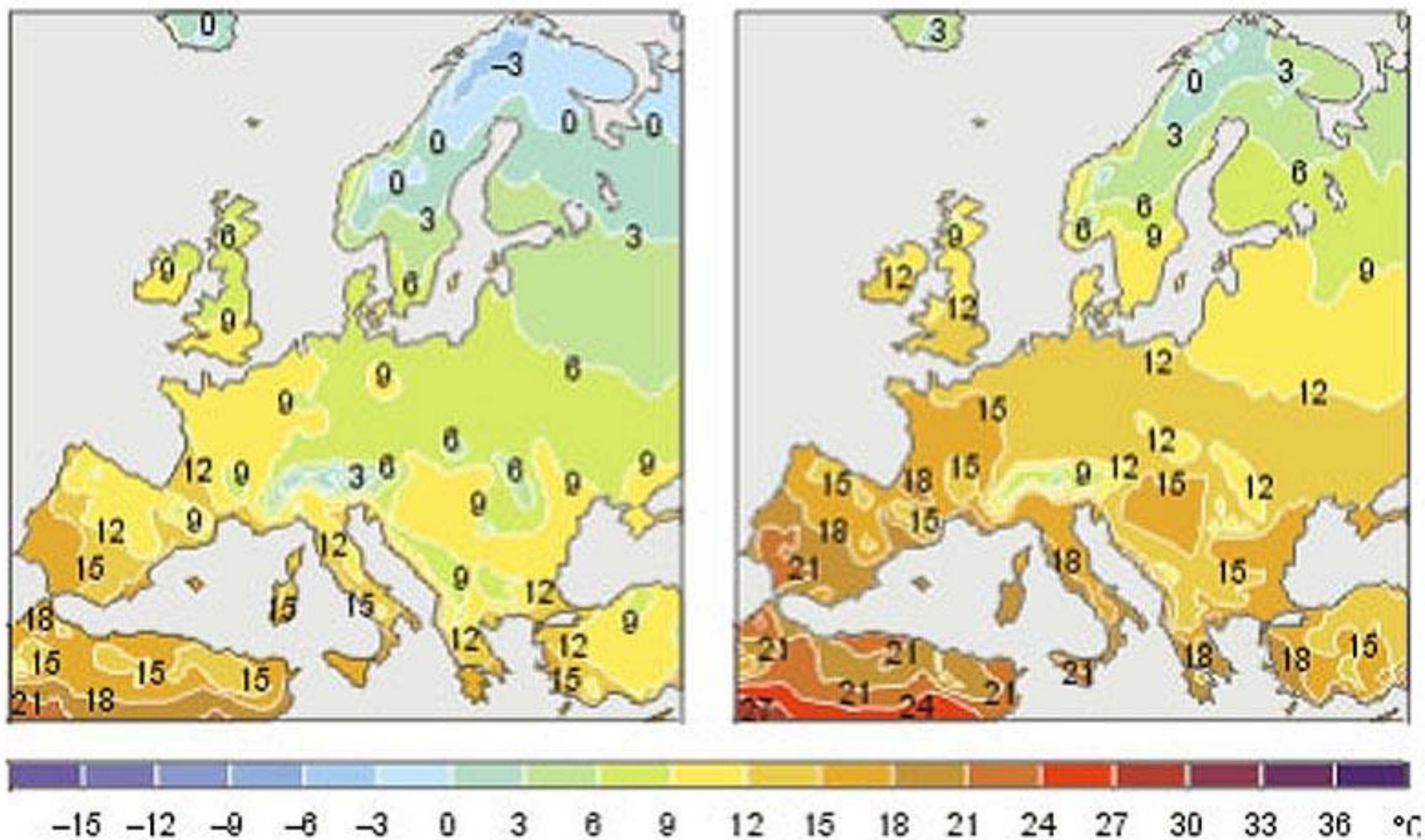


Source: Sweclim/Naturvardsverket 11

Natural systems can adapt much less…

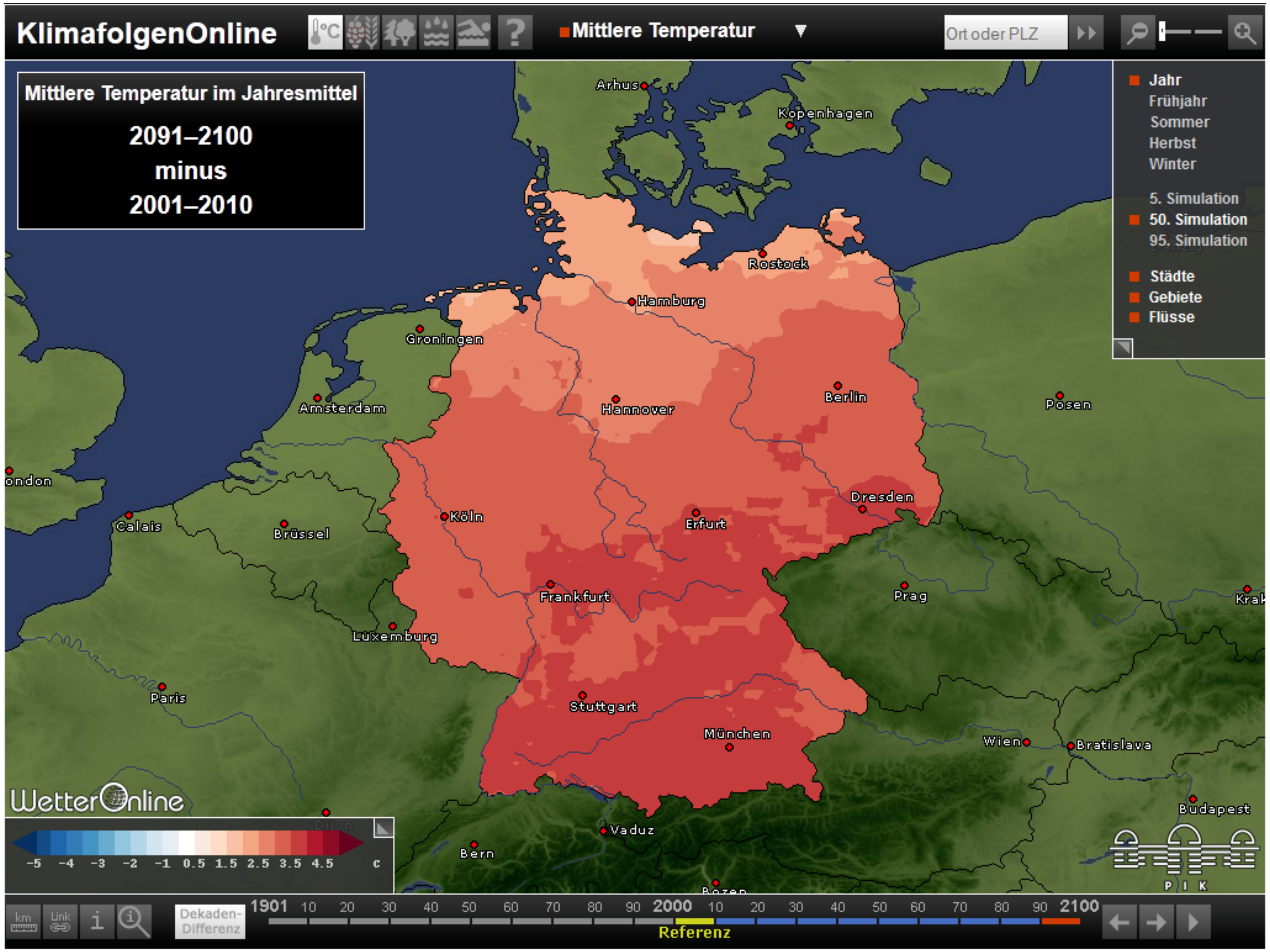


Managed systems can adapt better



Source: Sweclim/Naturvardsverket

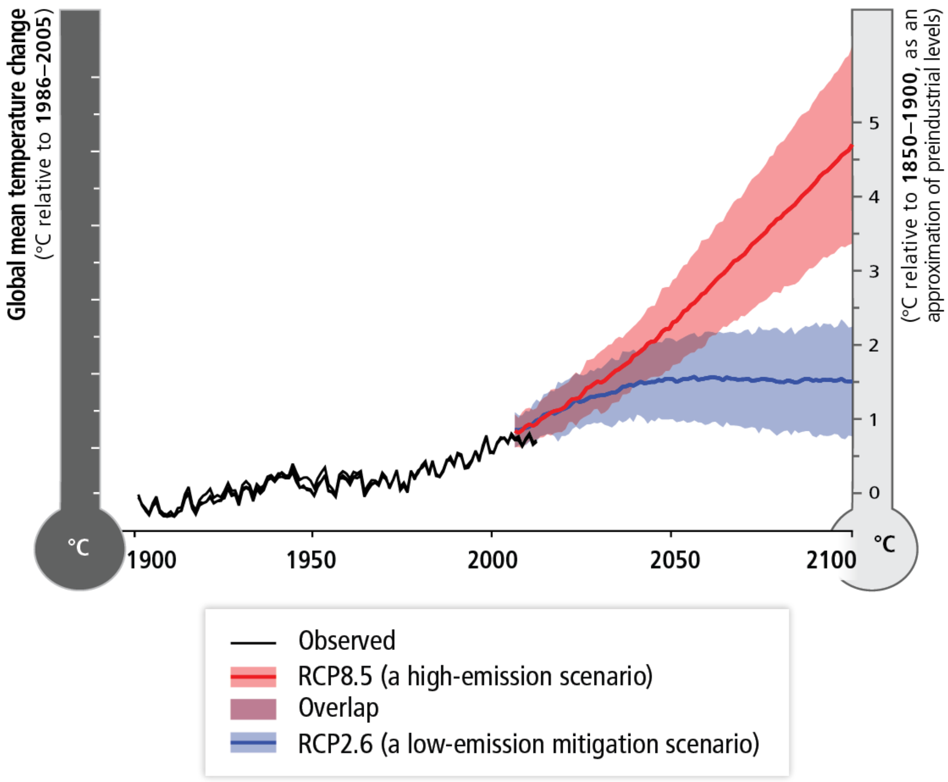
www.klimafolgenonline.com

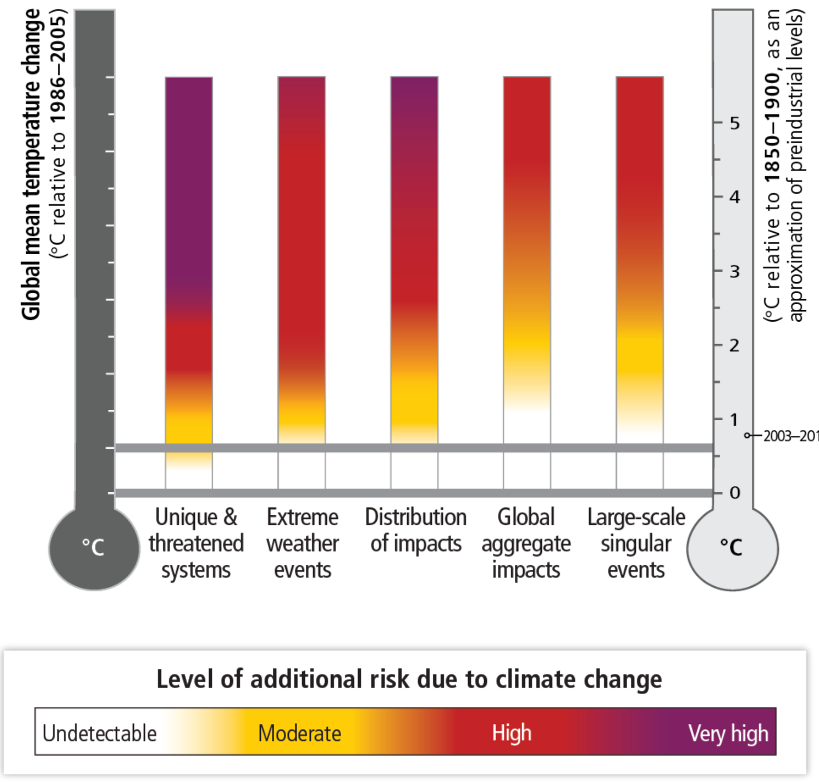


http://www.digibib.tu-bs.de/?docid=00059308

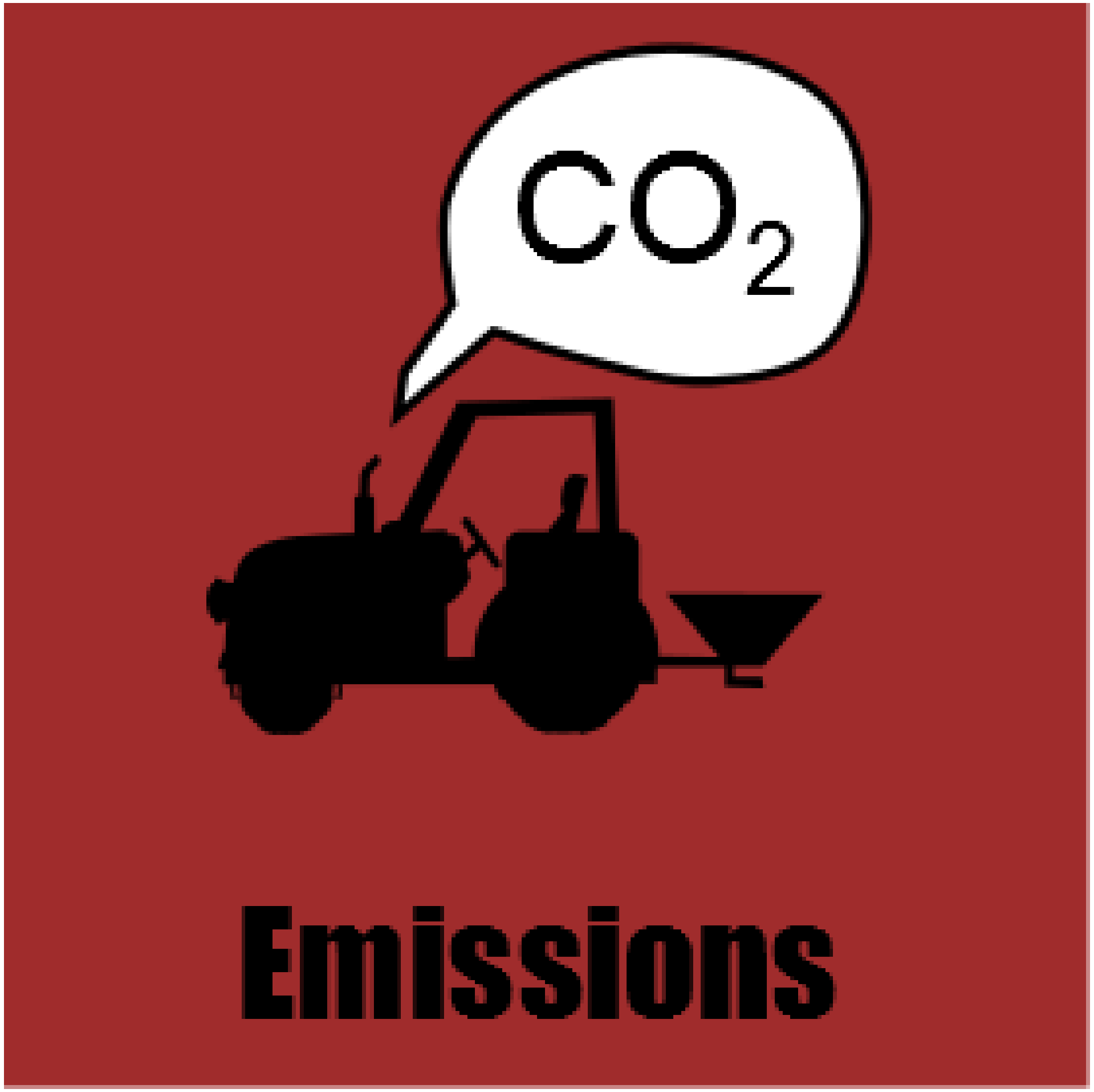
18/03/2015

Why should we limit warming to 2°C?





ipcc
INTERGOVERNMENTAL PANEL ON climate change


CO2
Emissions

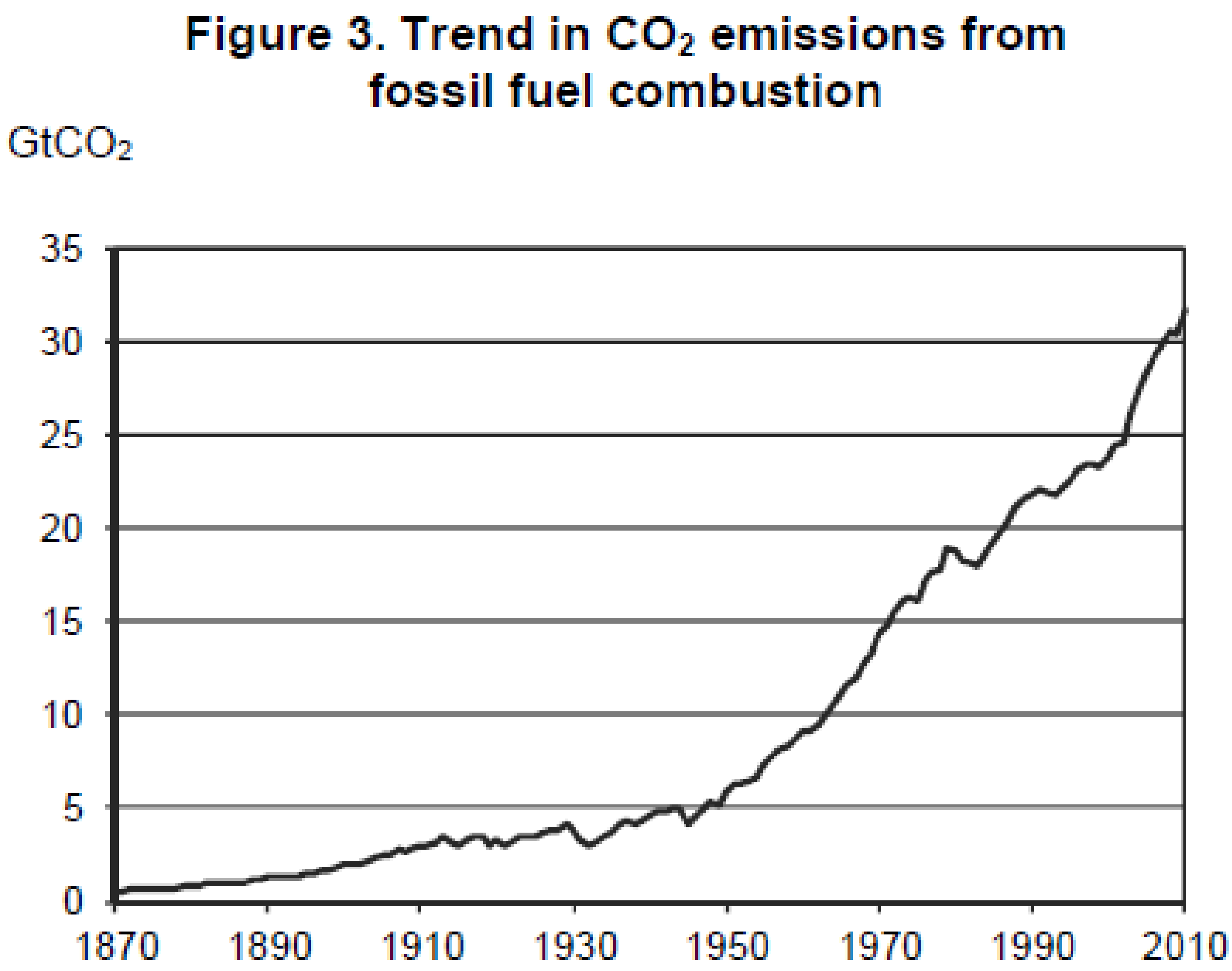
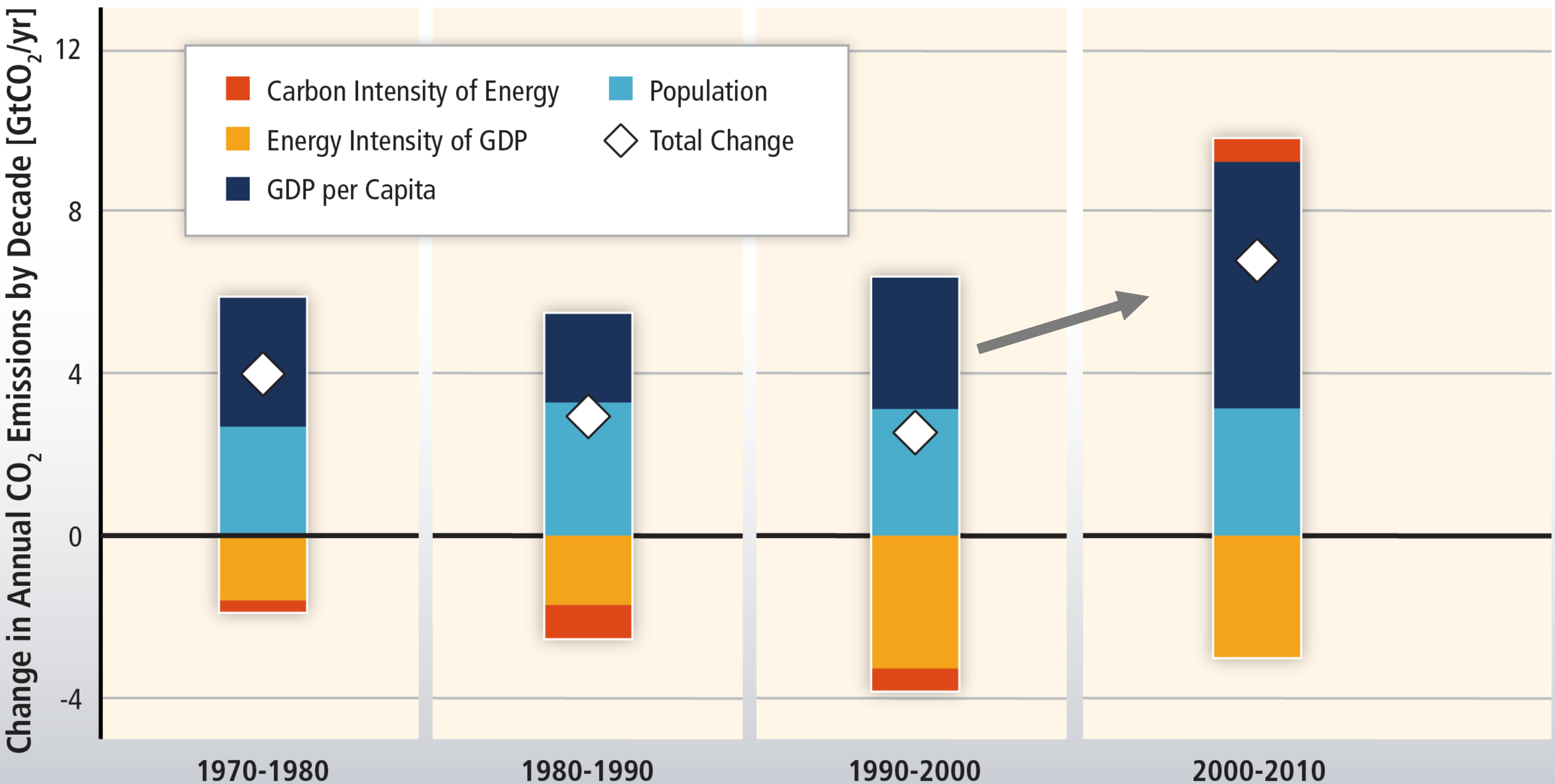


Figure 3. Trend in CO_2 emissions from fossil fuel combustion
$GtCO_2$
35
30
25
20
15
10
5
0
1870
1890
1910
1930
1950
1970
1990
2010

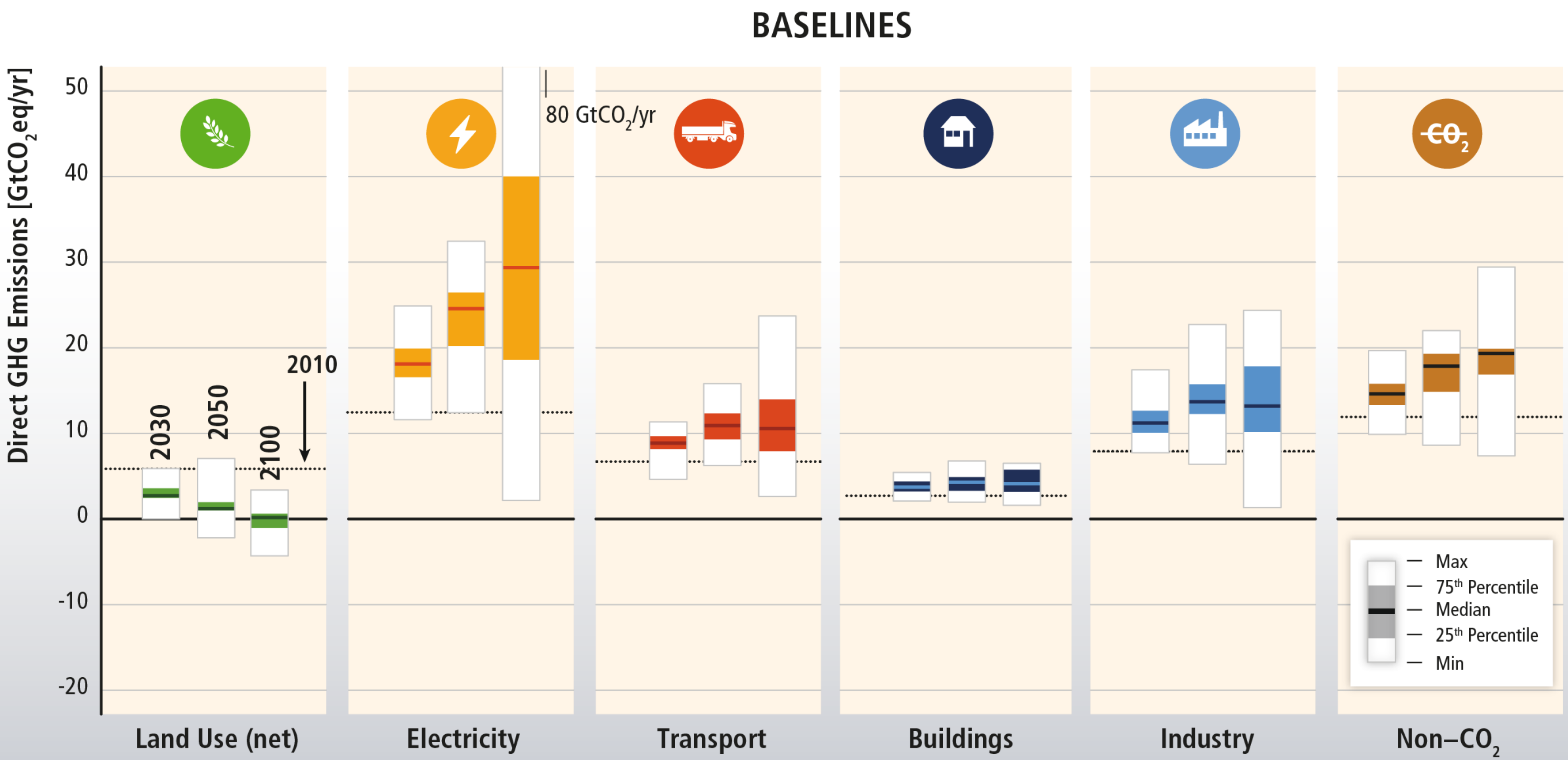
IEA 2014

GHG emissions rise with growth in GDP and population.



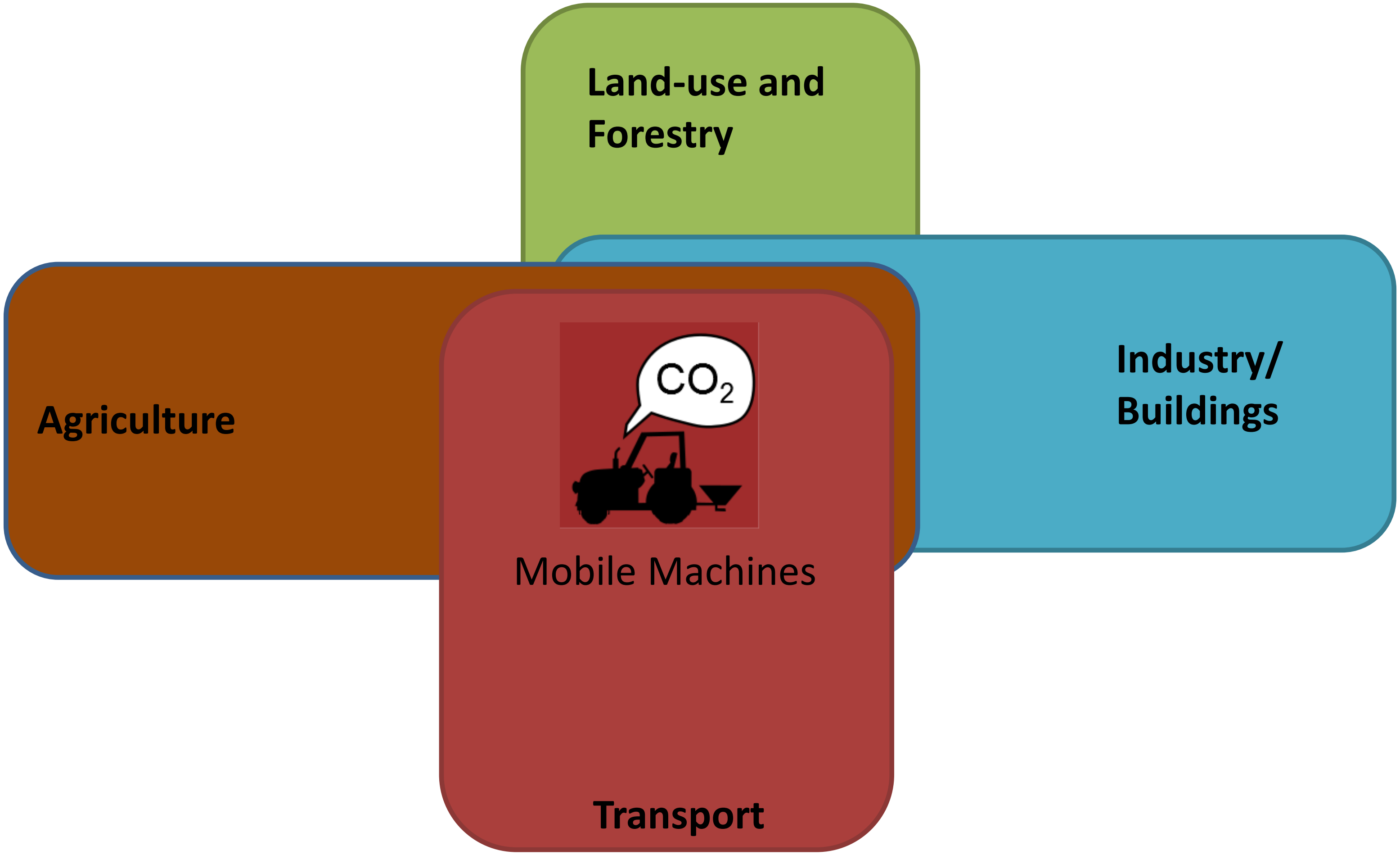
Based on Figure 1.7

Baseline scenarios suggest rising GHG emissions in all sectors, except for CO_2 emissions from the land-use sector.



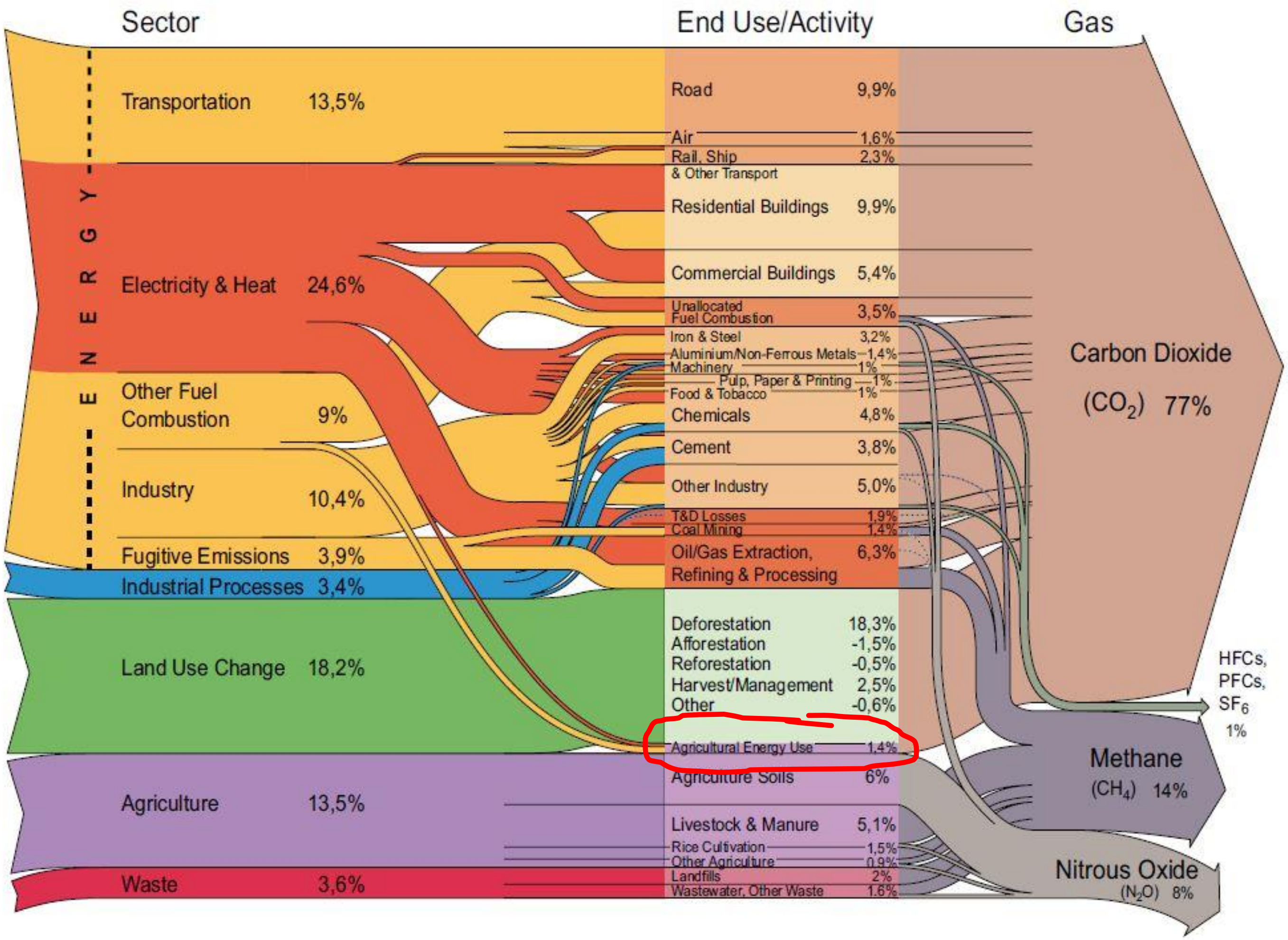
Based on Figure TS.15

Searching for emissions from Mobile Machines…



 18/03/2015

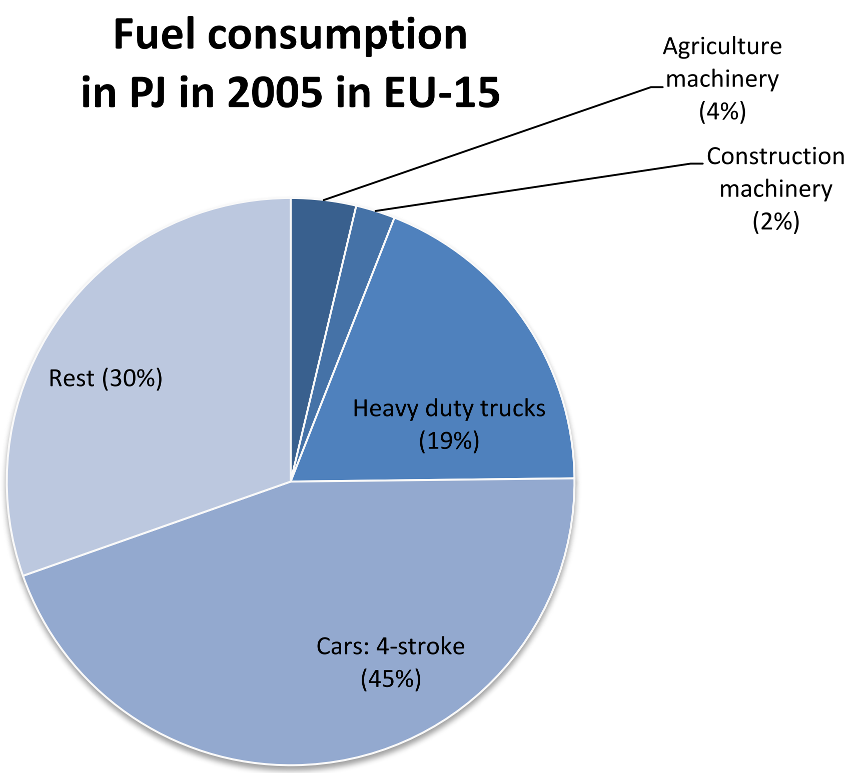
Global sectoral breakdown…



All data is for 2000. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41 755 $MtCO_2$ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

Baumert et al (2005)

European breakdown of transport fuel use…



Source: JRC 2008

European breakdown of emissions from mobile machines (including tractors)…

Table 14 : Relative importance of NRMM-sectors (GHG-emissions) compared to road transport

NRMM-sector	Our study	Belgium	Finland	Germany	Sweden	The Netherlands	UK
Construction and industry	6,5%	3,2%	11,3%	2,9%	8,8%	5,4%	7,7%
Generator sets	2,0%		1,0%				
Inland Waterways Transport	0,9%	2,4%		0,6%		5,8%	
Rail	0,7%	0,6%	1,0%	0,9%	0,3%	0,3%	2,1%
Agriculture and forestry	6,6%	2,1%	6,9%	3,8%	5,0%	4,2%	3,5%
Agriculture and forestry (excluding tractors)	*0,6%*		*2,5%*		*2,2%*		
Hobby and garden equipment	0,2%	0,7%	0,8%	0,2%	0,7%	0,5%	0,3%
Total NRMM (including tractors)	16,9%	9,1%	21,0%	8,5%	14,8%	16,1%	13,5%
Total NRMM (excluding tractors)	10,9%	7,5%	16,6%	5,4%	12,0%	12,8%	10,7%

Study for EC DG Enterprise, 2010

Non-CO2 emissions from mobile machines

- 15% of NOx and 5% of PM (EC 2014)
- NOx may be even more dangerous if emitted close to ammonia (NH3) (Gu 2014)
- Interrelation to agricultural emissions (e.g. through soil compaction, n2o emissions, …)

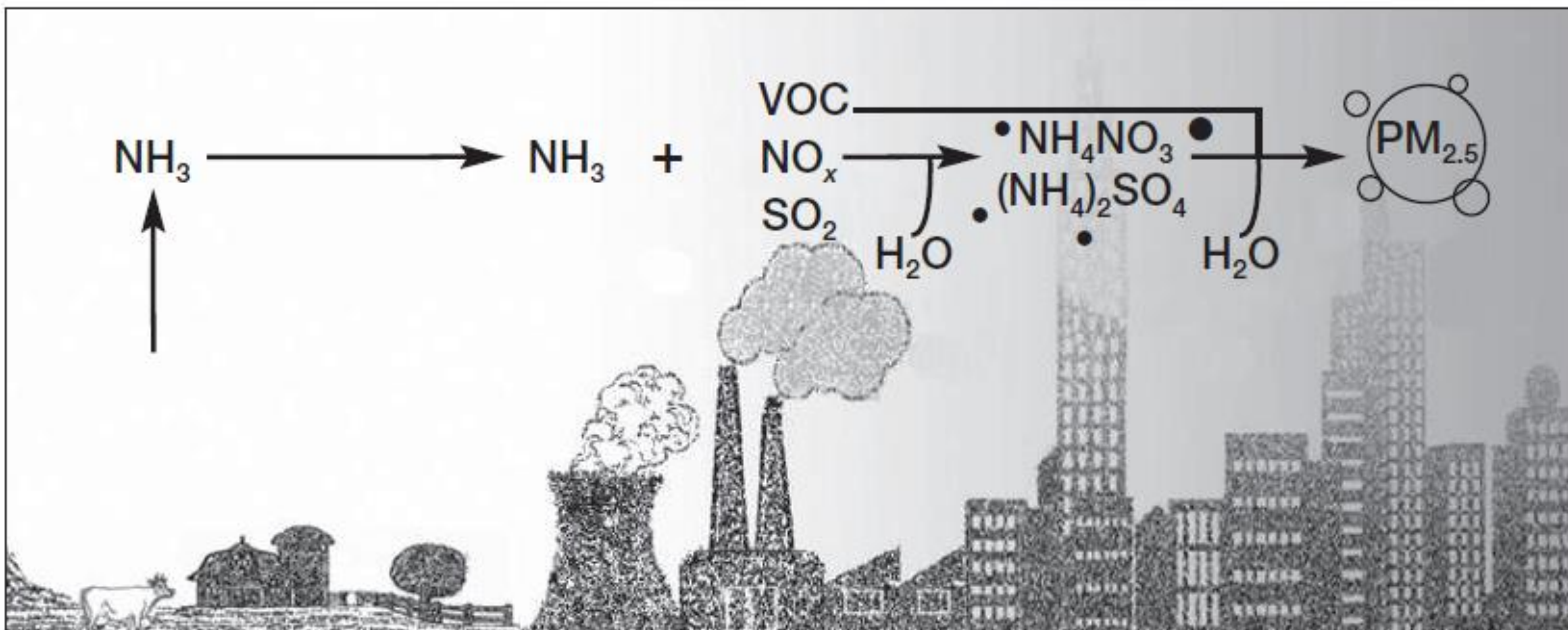
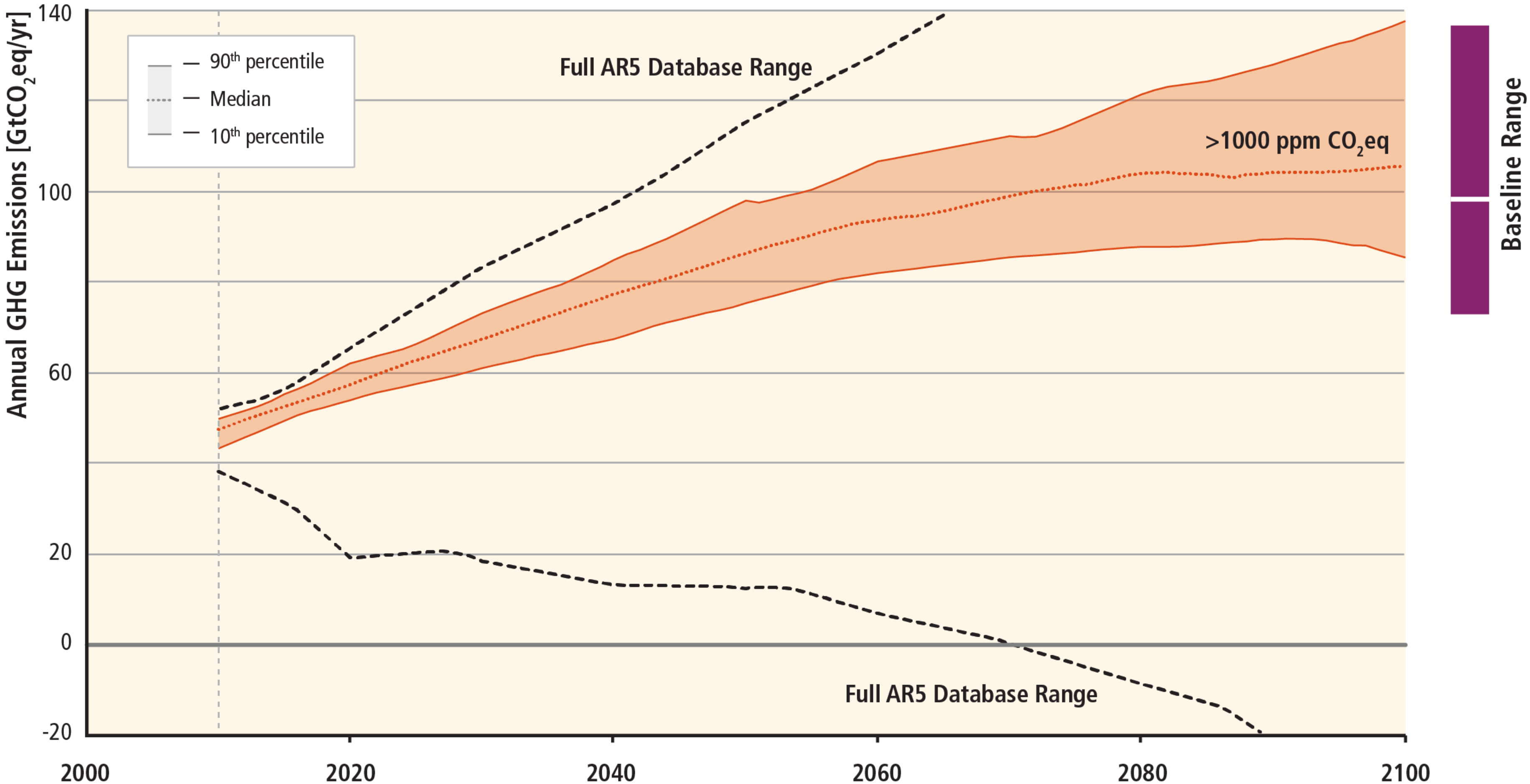


Figure 1. *Schematic depicting the formation of $PM_{2.5}$ from NH_3 and other air pollutants. VOC = volatile organic compound.*

Gu 2014

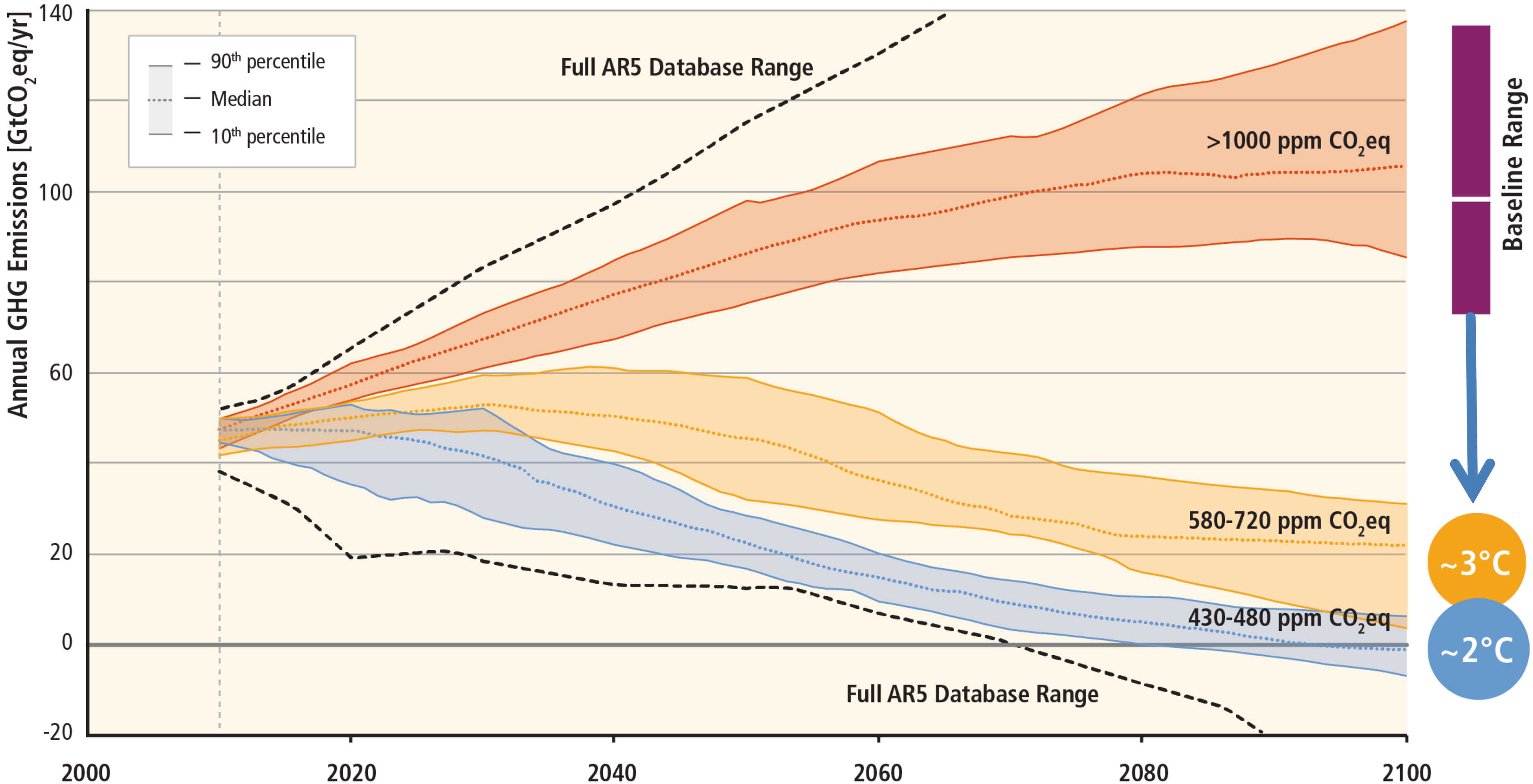

CO_2
Mitigation

Stabilization of atmospheric GHG concentrations requires moving away from business as usual.



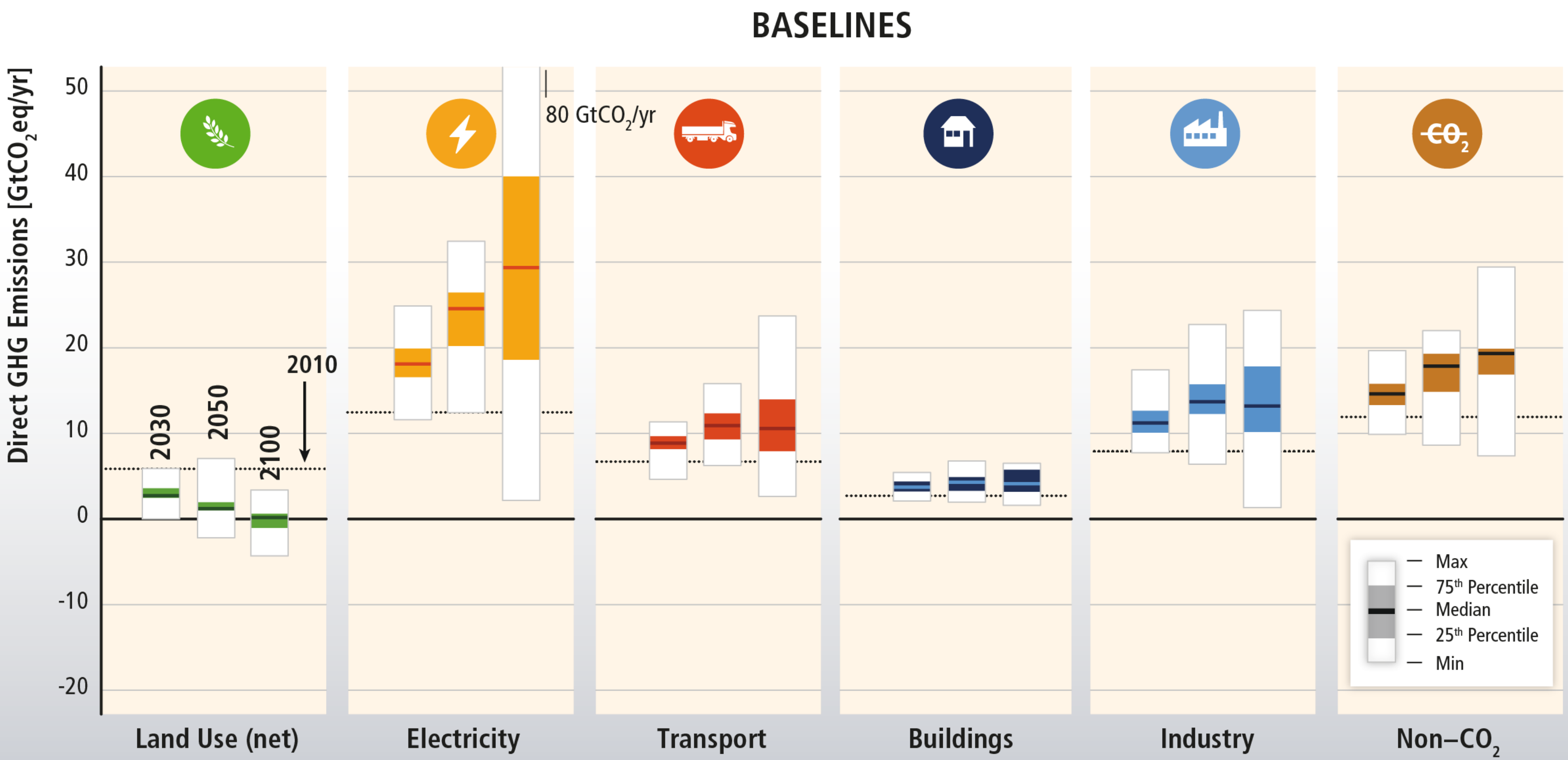
Based on Figure 6.7

Lower ambition mitigation goals require similar reductions of GHG emissions.



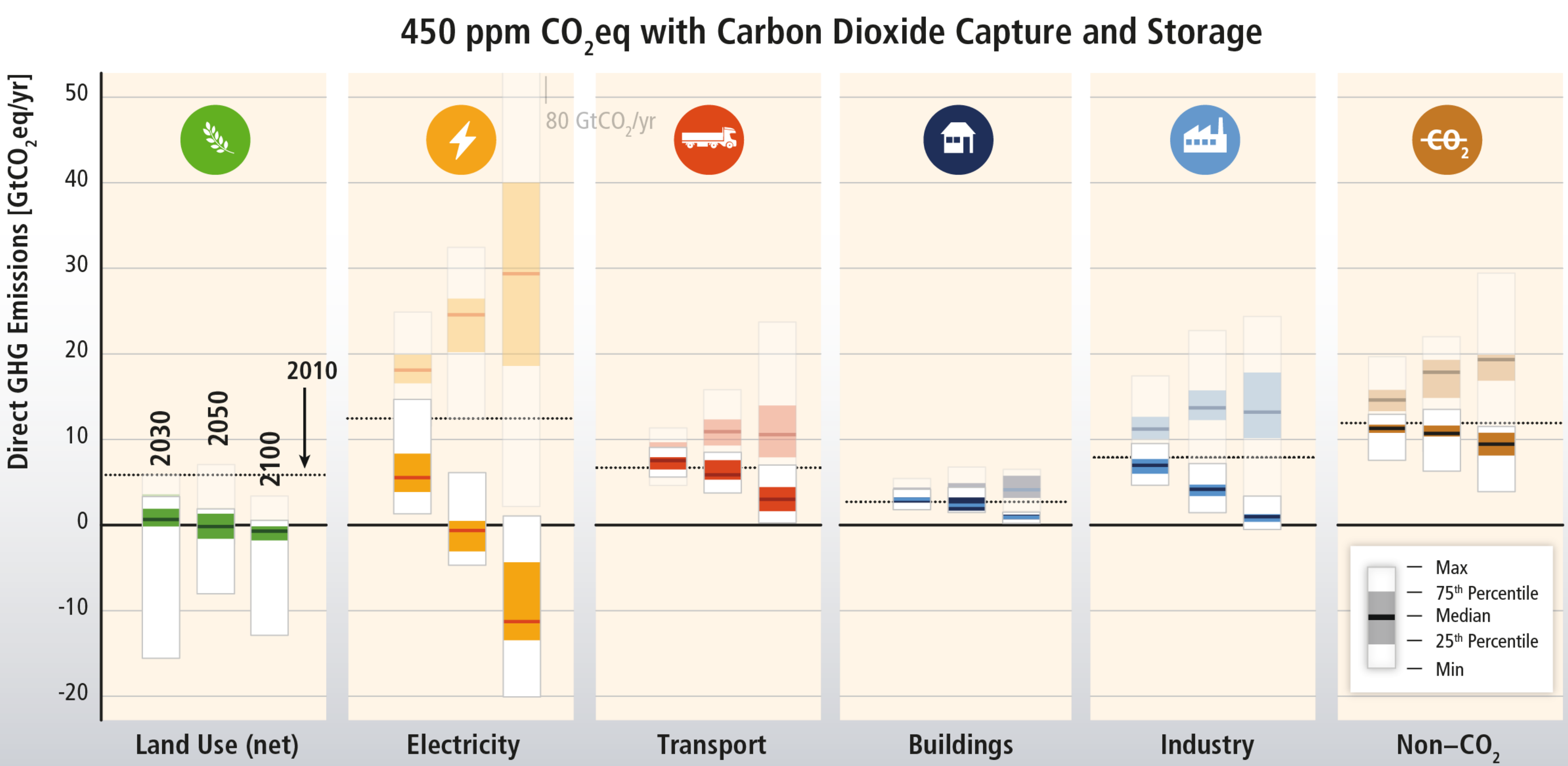
Based on Figure 6.9

Baseline scenarios suggest rising GHG emissions in all sectors, except for CO_2 emissions from the land-use sector.



Based on Figure TS.15

Mitigation requires changes throughout the economy. Systemic approaches are expected to be most effective.



Based on Figure TS.17

How to mitigate?

- Reduce consumption
  (e.g. food demand → agricultual production → tractor use)
- Substitute polluting production factors
  (e.g. precision farming)
- Increase energy efficiency
  (e.g. better combustion engines, hybrids, downsizing)
- Decrease emission intensity of fuels
  (e.g. biofuels)
- Remove emissions through negative emissions
  (e.g. afforestation)

How to mitigate?

- Reduce consumption
  (e.g. food demand → agricultual production → tractor use)
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  (e.g. afforestation)

Table 19: Summary of potential initiatives for (larger) diesel engines in working machinery / equipment – engine and machine level

	Initiative, development or measure	Reduction potential	Drawbacks
1) Engine / components	Improvements to combustion and air handling: • *Common-rail* • *Turbocharging*	5% to 25%, depending on the source The total potential is often a function of a (different) combination of measures.	• Cost increase of the engine 15% to 20%. • Increased sensitivity to water and ambient weather conditions
	Improvement to (NOx) after treatment systems		
	Improvements to base engine design	15 – 25%	
	Engine auxiliaries: • *2-Speed oil pump / electric* • *Variable flow water pump / electric*	0,5 - 4%	• Engine cost up with 1 to 5% • Durability concerns and lack of market acceptance for the electric version
2) Machine systems and integration	Efficient power trains and new transmission technologies (continuously variable transmissions, CVT)	5%	Collaboration between engine builders and OEM-manufacturers. Consolidation?
	Improvements to the hydraulics and steering system		Cost increase due to additional hydraulic or electric components.

Study for EC DG Enterprise, 2010

Table 19: Summary of potential initiatives for (larger) diesel engines in working machinery / equipment – engine and machine level

	Initiative, development or measure	Reduction potential	Drawbacks
	Downsizing	15%[54]	Decreased engine durability due to higher specific load (downsizing)
	Energy conversion systems[55]: • *Waste heat recovery* • *Hybridization and energy storage*	• 15 to 25 % for heat recovery. Different sources (one respondent stated only 1,8% gain for heat recovery) • Up to 30% or even more for hybrid power packs (limited to 6% for mild hybrids[57])	• LCA-analysis? GHG from hybrid systems production process, additional consumption of natural resources (copper, silicium, etc.) • Additional weight and complexity of hybrid systems could increase fuel consumption / CO_2 when there is little opportunity for energy recovery. • Negative effect on after treatment efficiency (cooling down exhaust) • Engine cost up 5 to 40% for waste heat recovery systems[56] • Over 100% engines cost increase for (full) hybrids[57].
	Control systems: • *Engine control systems / power control systems* • *On-demand cooling, controlled fan (hydro fan or electric driven fan)* • *Engine idle control or abatement systems*		

Conclusions

Conclusions

- Climate Change is happening and has already impacts

Approach to reducing GHG in agriculture

Annette Freibauer

Thünen Institute of Climate-Smart Agriculture

Braunschweig
11.03.2015

Overview

- Agriculture: production, climate and environment challenges
- GHG sources and sinks in agriculture
- Mitigation options
  - N_2O and NH_3 reduction by N efficiency
  - GHG reduction by wet peat soil management
- Outlook

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Agriculture: production, climate and environment challenges

“Many of today´s food production systems compromise the capacity of Earth to produce food in the future”. *SCAR Foresight 3*

“In order to feed the larger, more urban and richer population in 2050, food production (net of food used for biofuels) must increase by 70 percent”
How to feed the world in 2050 (FAO 2009)

Closing the yield gap world-wide requires more than 4-fold higher N efficiency (reduced loss) in Europe to meet the planetary N boundary
Derived from Rockström et al. 2009

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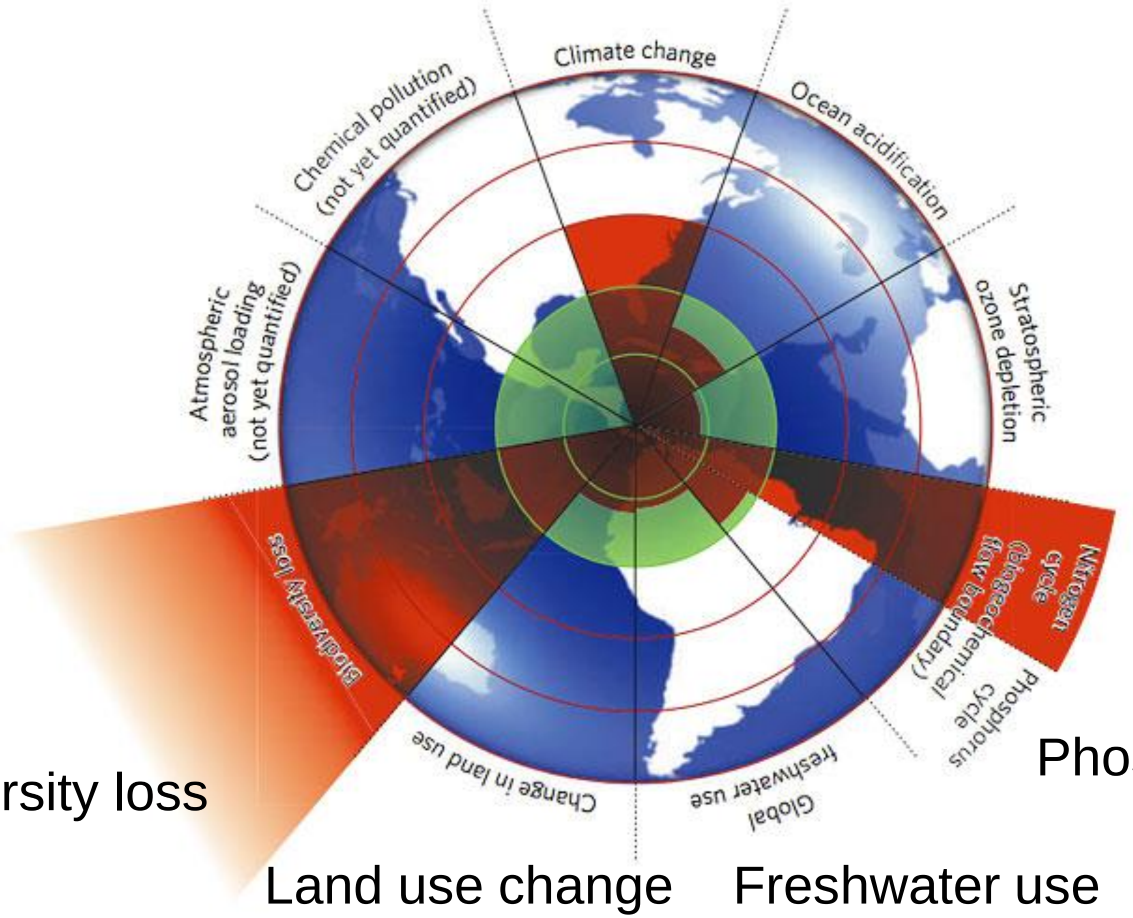
Planetary boundaries



The strong global limits: many related to agriculture –
A drastic change is needed

Nitrogen

Phosphorus

Biodiversity loss

Land use change

Freshwater use

Rockström et al. 2009

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THÜNEN

Greenhouse gas sources from agriculture

N_2O Emissions

N Fertilization
N Management

CH_4 Emissions

Animal husbandry

CO_2 Emissions

Peatland use
Land use change
Energy

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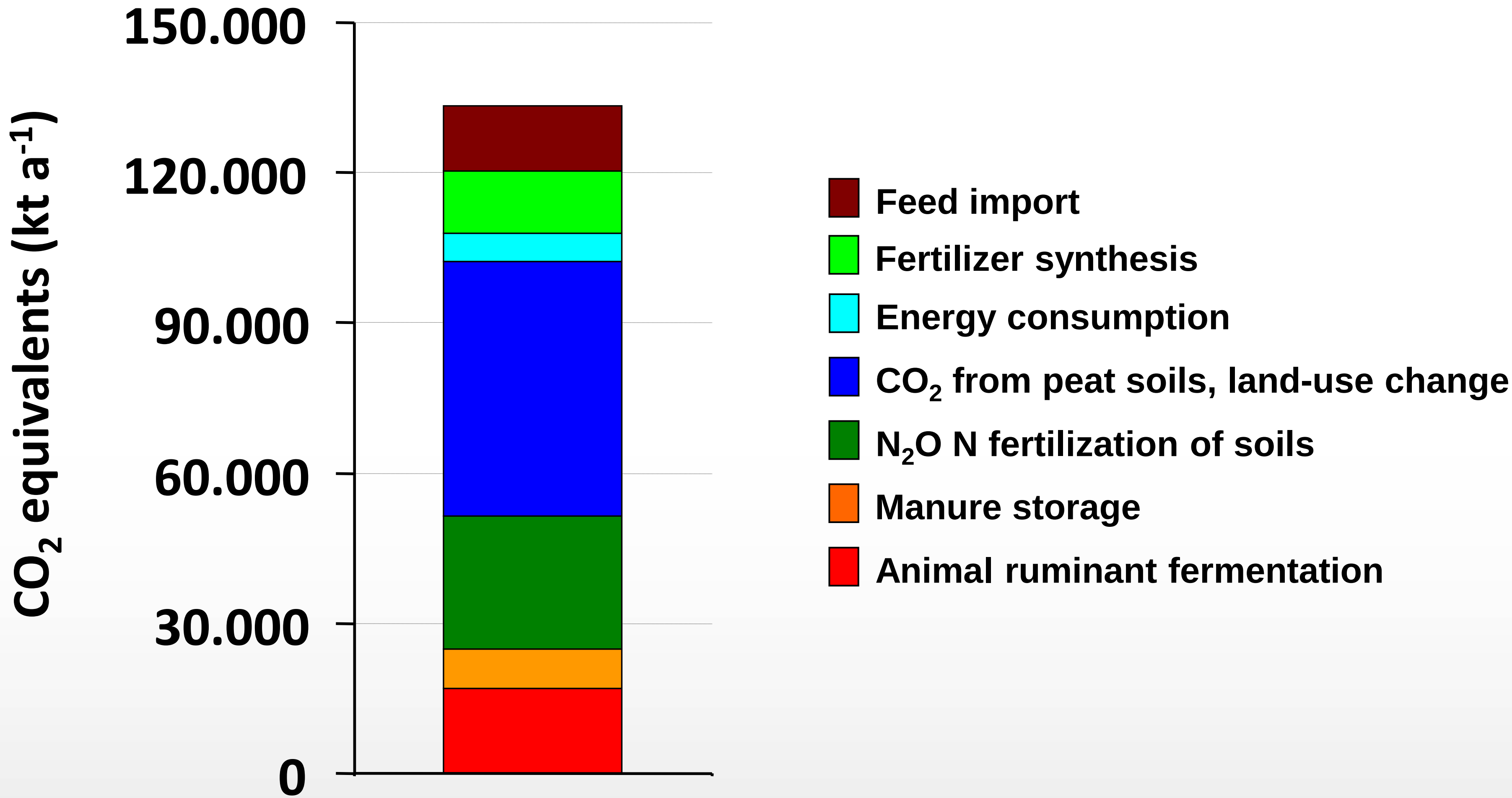
GHG emissions from German agriculture



10.000 kt CO_2 equivalents = 1% of German GHG emissions

NIR 2013

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GHG mitigation options

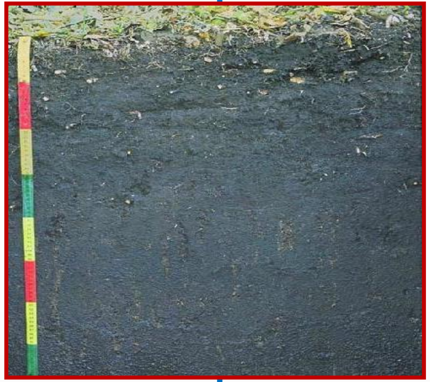
Improve N efficiency
Reduce / avoid N surpluses

Fertilizer

Feeding

Manure chain

Maintain soil organic matter
Reduce humus losses



Humus balance

Grassland

Peatlands, organic soils

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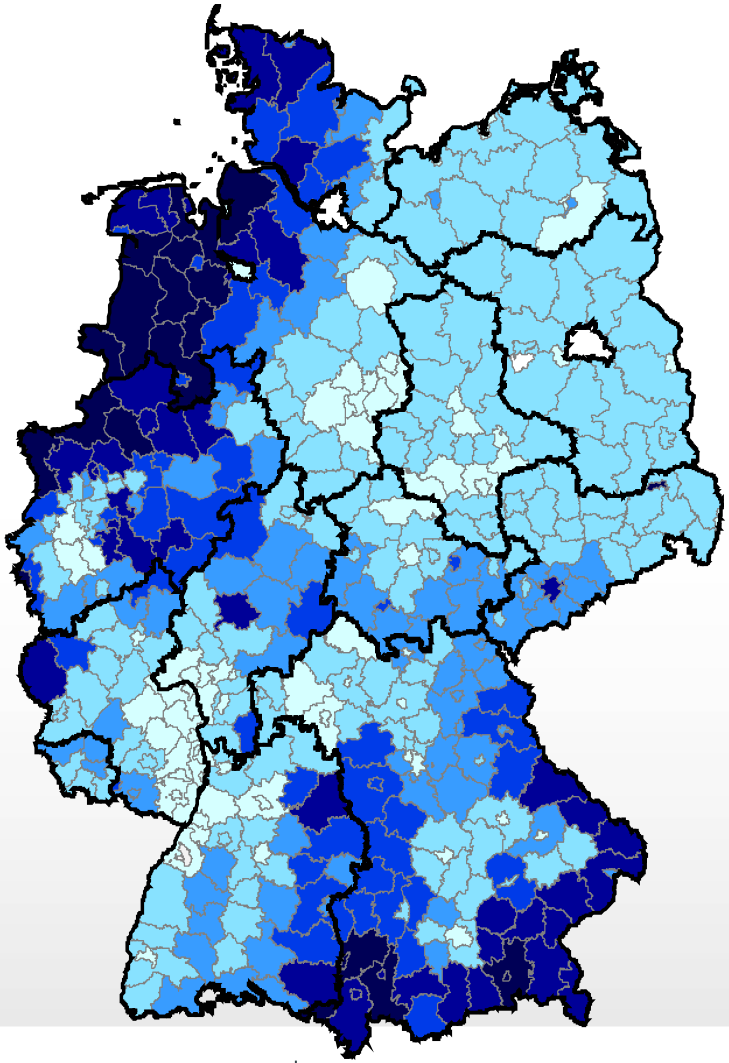
Improved N efficiency reduces N_2O



N- su

in kg

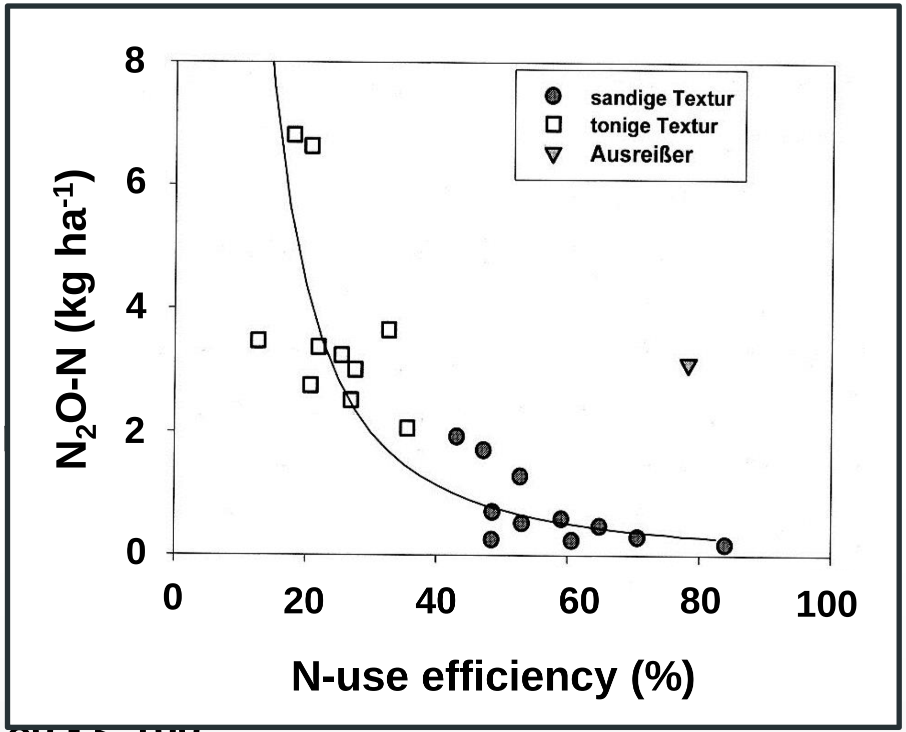
80 - < 100

100 - < 120

120 - < 150

> 150

No values



van Groenigen, 2004

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THÜNEN

Improved N efficiency reduces N_2O

- Reducing 1 kg of unused N reduces GHGs in 3 ways
- N sensors for soil Nmin and N content in manure, digestate etc. for demand-driven application
- N recycling and legumes in agriculture

	GHG reduction ($kg\ CO_{2\text{-}equ.}$ / kg N)
Direct N_2O Emission*	**6.1**
Indirect N_2O Emission*	**3.9**
Synthetic fertilizer production**	**7.5**
Sum	**17.5**

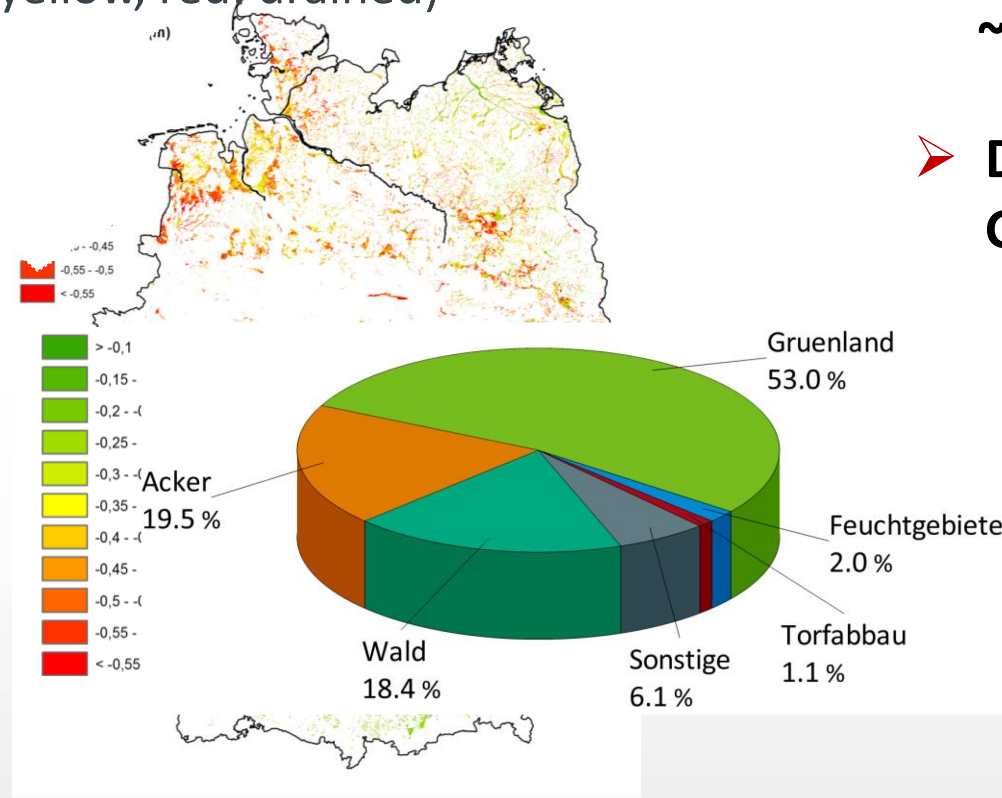
*IPCC, 1996 and German mineral fertilizer mix
** www. Probas.umweltbundesamt.de

Flessa et al. 2013

GHG hotspot drained organic soils: one of the largest GHG sources in 8 EU States

Water table in organic soils

(yellow, red: drained)



- **Organic soils (~peatlands) = ~5% of German area (1.8 Mio ha)**
- **Drained organic soils = 4-5% of German GHG emissions**

(Bechtold et al. 2014)

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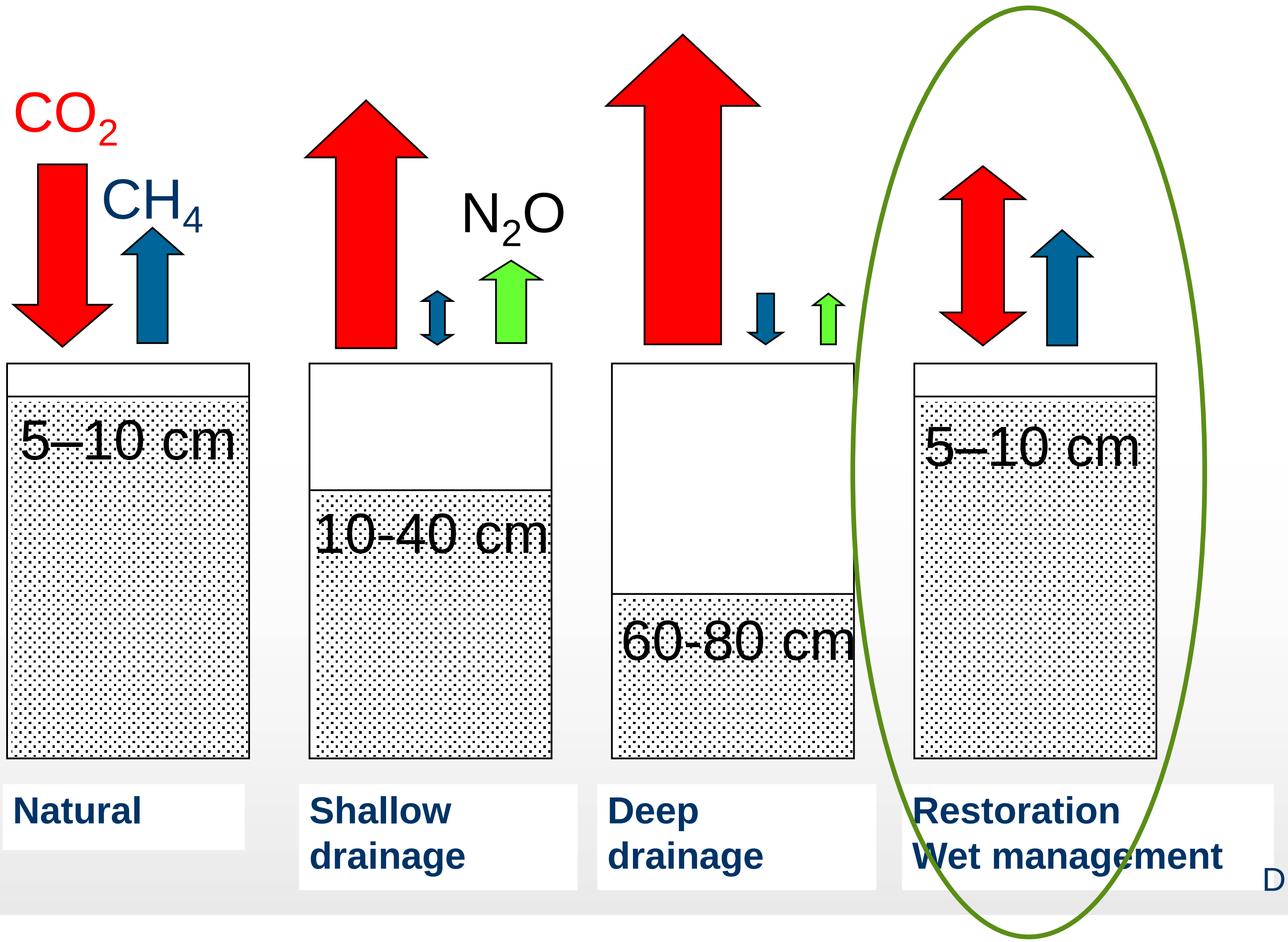
GHGs and water table in organic soils



Drösler et al. 2008

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THÜNEN

Wet management challenges

- Innovative water table management

- Wetness-adapted cultures and grassland → new markets?

- Trafficability of wet organic soils → adapted mobile machines

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Outlook

- GHG mitigation in agriculture: zero to -20% since 1990
- Agriculture dominates GHG outside ETS: ACTION NEEDED
- Biology constrains maximum GHG mitigation
  - Efficiency and nutrient recycling
  - Sufficiency and consumer choices
- Technology and innovation needed
- The real constraint: fertile land
  → cascade use is key: food first, fibre second, energy third!

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THÜNEN

Annette.freibauer@ti.bund.de

ENERGIE- UND CARBONMANAGEMENT IM BAUWESEN

RALF LÜDDEMANN

SYMPOSIUM EFFICIENCY OF MOBILE MACHINES AND THEIR APPLICATIONS | BRAUNSCHWEIG | 11. MÄRZ 2015 |

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GLIEDERUNG

1 RAHMENBEDINGUNGEN FÜR ENERGIE- UND CARBON-MANAGEMENT IN DER BAUINDUSTRIE

2 STATUS QUO UND AUSBLICK "ENERGIE- UND CARBON-MANAGEMENT IN **STRABAG**„

3 ANFORDERUNGEN DER BAUINDUSTRIE AN DIE HERSTELLER MOBILER ARBEITSMASCHINEN

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INTRO

REFERENT

- **RALF LÜDDEMANN**
- Geschäftsführer BMTI Baumaschinentechnik Int. GmbH & Co. KG
- Zentralsbereichsleiter Maschinentechnik in STRABAG SE

BMTI

- Maschinentechnischer Dienstleister in STRABAG SE
- Betriebsmanagement Baumaschinen und Fuhrpark von A – Z
- Investition – Einkauf – Vermietung – Service – Dienstleistungen
- Baustellenversorgung von Kiruna bis Daressalam und Köln bis Nepal

BMTI IN ZAHLEN

- 150 Standorte
- 2.400 Mitarbeiter
- 18 Länder
- Verwaltetes Anlagevermögen ca. 5 Mrd. EURO
- Ca. 250.000 Inventarnummern

  → davon ca. 70.000 mit Verbrennungsmotor

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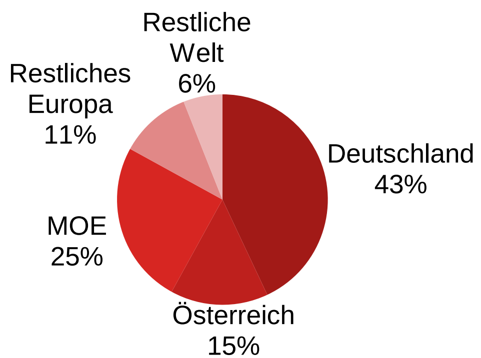
STRABAG AUF EINEN BLICK

FACTS & FIGURES

- Leistung 2013: € 13,6 Mrd.
- Konzernergebnis 2013: € 114 Mio.
- 73.100 Mitarbeiterinnen und Mitarbeiter
- > 500 Standorte in mehr als 80 Ländern
- 1.600 Mitarbeiterinnen und Mitarbeiter wirken bei Forschungs- und Entwicklungsvorhaben mit
- Eigenkapitalquote: > 30%
- Starke Marken: STRABAG & Züblin

LEISTUNG NACH REGIONEN (2013)



Quellen: www.gtai.de, Geschäftsberichte

MÄRKTE

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WAS WIR MACHEN

STRABAG TEAMS WORK.


STRABAG
TEAMS WORK

auen Stahl Technologie
ZÜBLIN


STRABAG
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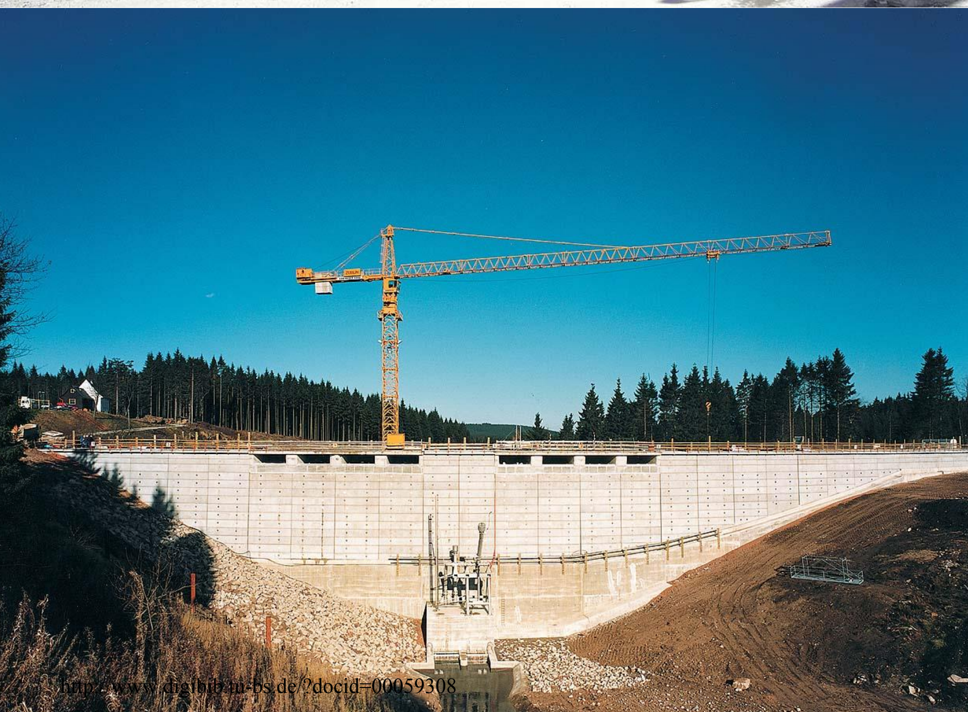

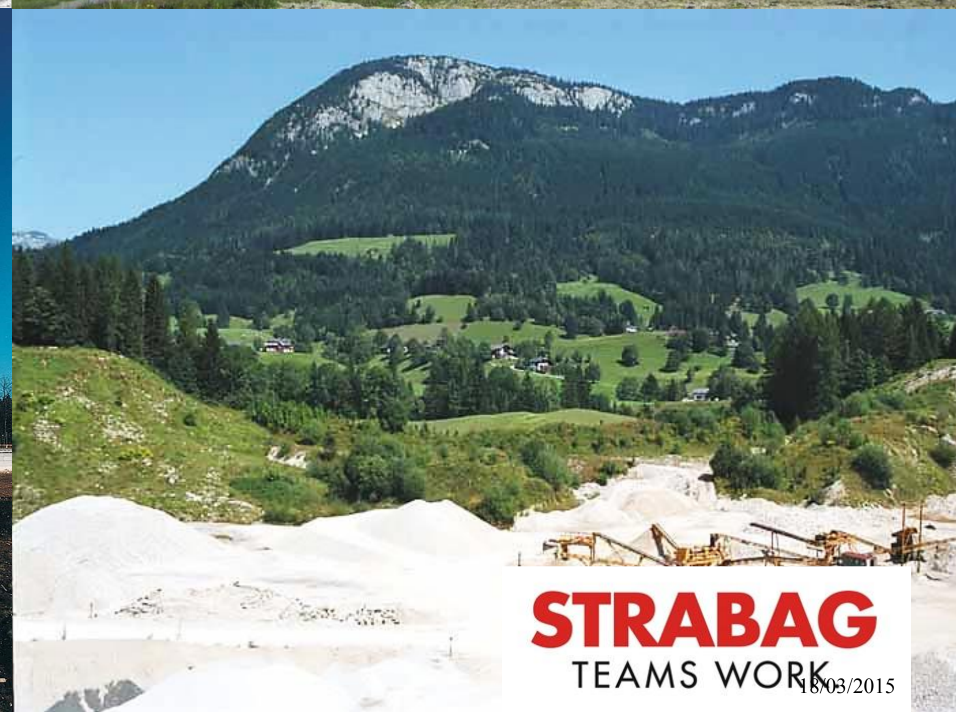
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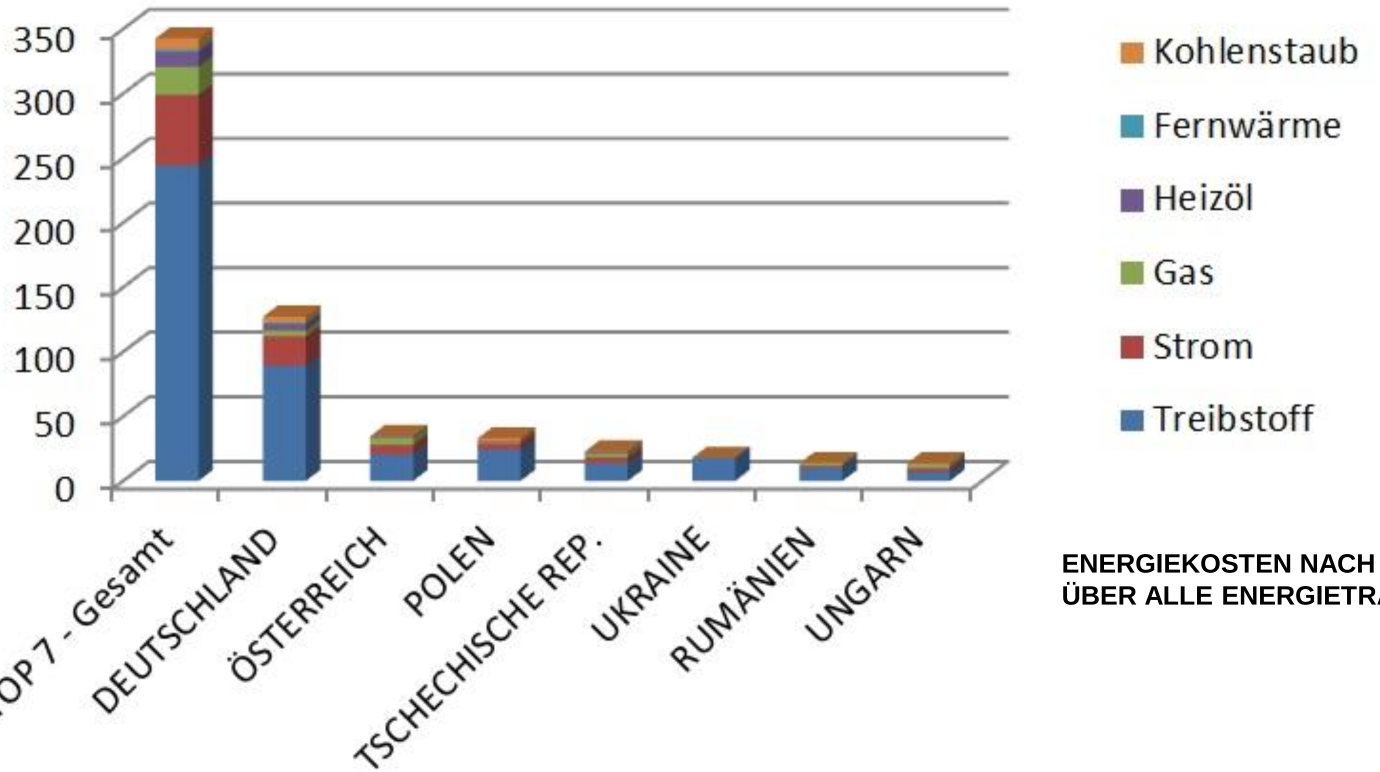
WELCHE ENERGIEN VERBRAUCHEN WIR ?

ERGEBNISSE DER ENERGIESTROM-ANALYSE

ENERGIEKOSTEN (MIO. EURO) IN 2013



ENERGIEKOSTEN NACH LÄNDERN (TOP7) ÜBER ALLE ENERGIETRÄGER

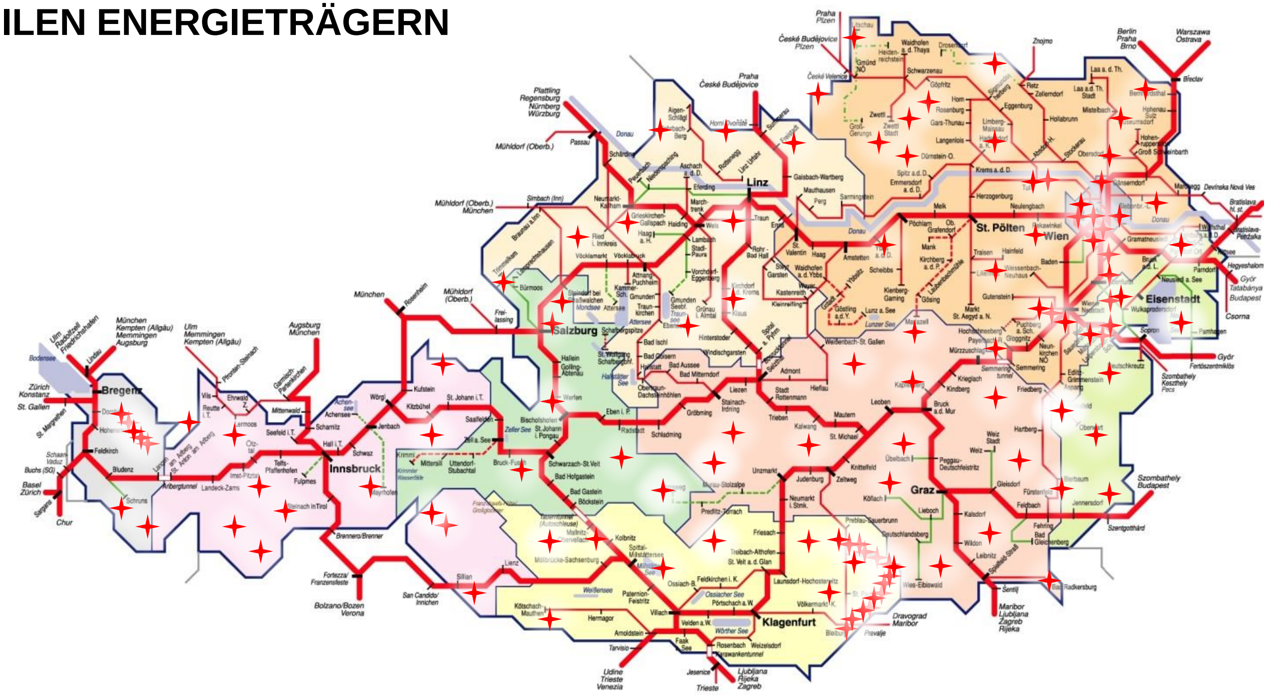
STRABAG TEAMS WORK.

PROBLEME UNSERER ENERGIE-INFRASTRUKTUR

DEZENTRALE BAUSTELLEN UND EINSATZORTE

BEWEGTE UND TEMPORÄRE PRODUKTIONSSTÄTTEN

ABHÄNGIGKEIT VON FOSSILEN ENERGIETRÄGERN



Quelle: Netzkarte ÖBB

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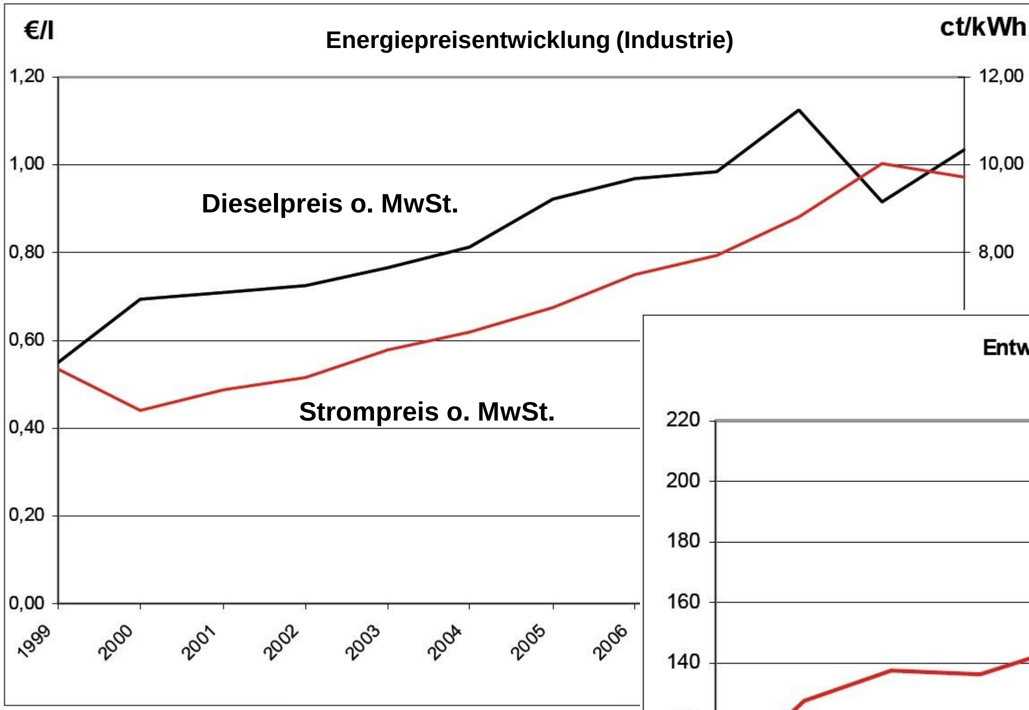
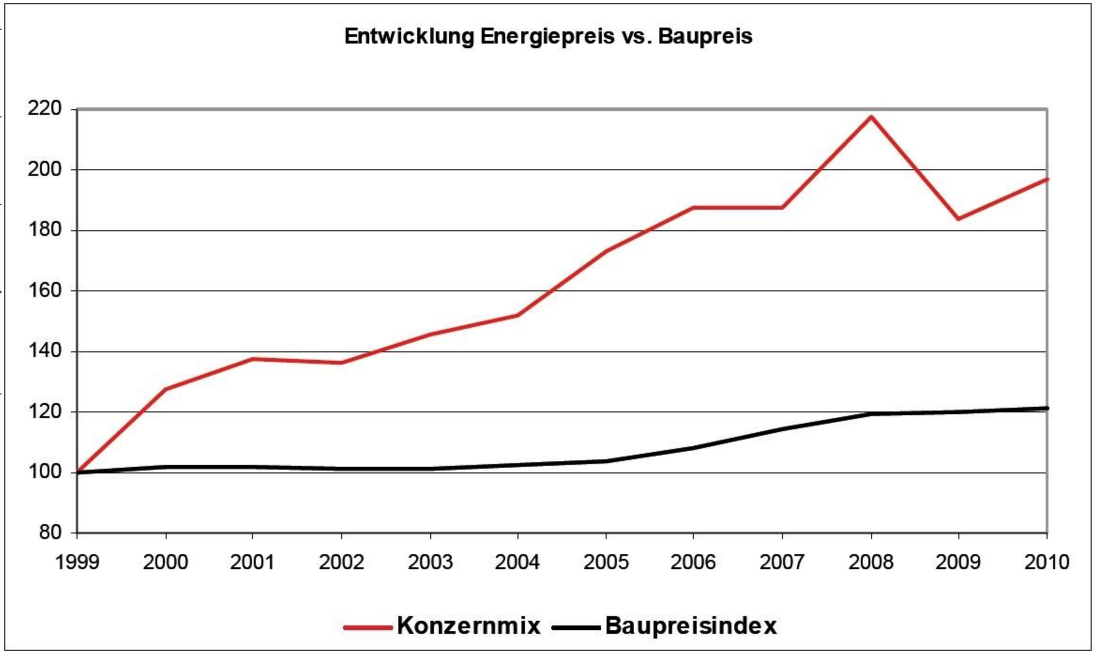
VERÄNDERTE RAHMEN-BEDINGUNGEN

KOSTENDRUCK DURCH STEIGENDE ENERGIEPREISE





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ENERGIEPOLITISCHE ANFORDERUNGEN

Europäische Kommission

DGNB®
Deutsche Gesellschaft für Nachhaltiges Bauen e.V.
German Sustainable Building Council

CO_2-PRESTATIELADDER©
Samen zorgen voor minder CO_2

ÖGNI
AUSTRIAN SUSTAINABLE BUILDING COUNCIL

bmvit

ÖGNB
Österreichische Gesellschaft für Nachhaltiges Bauen

klimaaktiv

U.S. GREEN BUILDING COUNCIL LEED USGBC™

WWF®

AUSTRIAN ENERGY AGENCY

UNEP

BREEAM®

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ENERGIEEFFIZIENZGESETZ IN ÖSTERREICH

- Das Gesetz setzt u.a. die gültige EU-Richtlinie 2012/27/EU zur Energieeffizienz um.

- Das Gesetz verpflichtet große Unternehmen in Österreich ab 01/2015 zur Einführung eines Energiemanagementsystems oder zur Durchführung von externen Energieaudits.

- Ziel des Gesetzes ist die kostenwirksame Steigerung der Effizienz der Energienutzung und die Energieeinsparung in Unternehmen und im Bund.

- Die wesentlichen Energieverbrauchsbereiche eines Unternehmens sind aufzuzeigen.

- wesentliche Energieverbrauchsbereiche der STRABAG sind u.a.:
  - **Prozess** (Produktion stationär und Baustellen)
  - **Transport** (Beförderungs- und Transportprozesse)

ENERGIEDIENSTLEISTUNGSGESETZ IN DEUTSCHLAND

- Verabschiedung des Gesetzesentwurfs im Bundesrat voraussichtlich im März 2015.

- Das Gesetz verpflichtet große Unternehmen in Deutschland bis 11/2015 zu Energieaudits nach DIN EN 16247-1 oder der Einführung eines Energiemanagementsystems.

- Mindestens 90% der gesamten Energieverbräuche eines Unternehmens müssen den energie-verbrauchenden Anlagen und Geräten des Unternehmens zugeordnet sein.

- Energieaudits müssen auf aktuellen, kontinuierlichen oder zeitweise gemessenen, belegbaren Betriebsdaten zum Energieverbrauch und zu den Lastprofilen basieren.

- *Aufgabe AT und DE: zukünftig müssen z.B. Energieverbrauchdaten von Großmaschinen, Großgeräten, etc. gemessen, dokumentiert und verglichen werden um so die Maschinen effizienter einsetzen zu können.*

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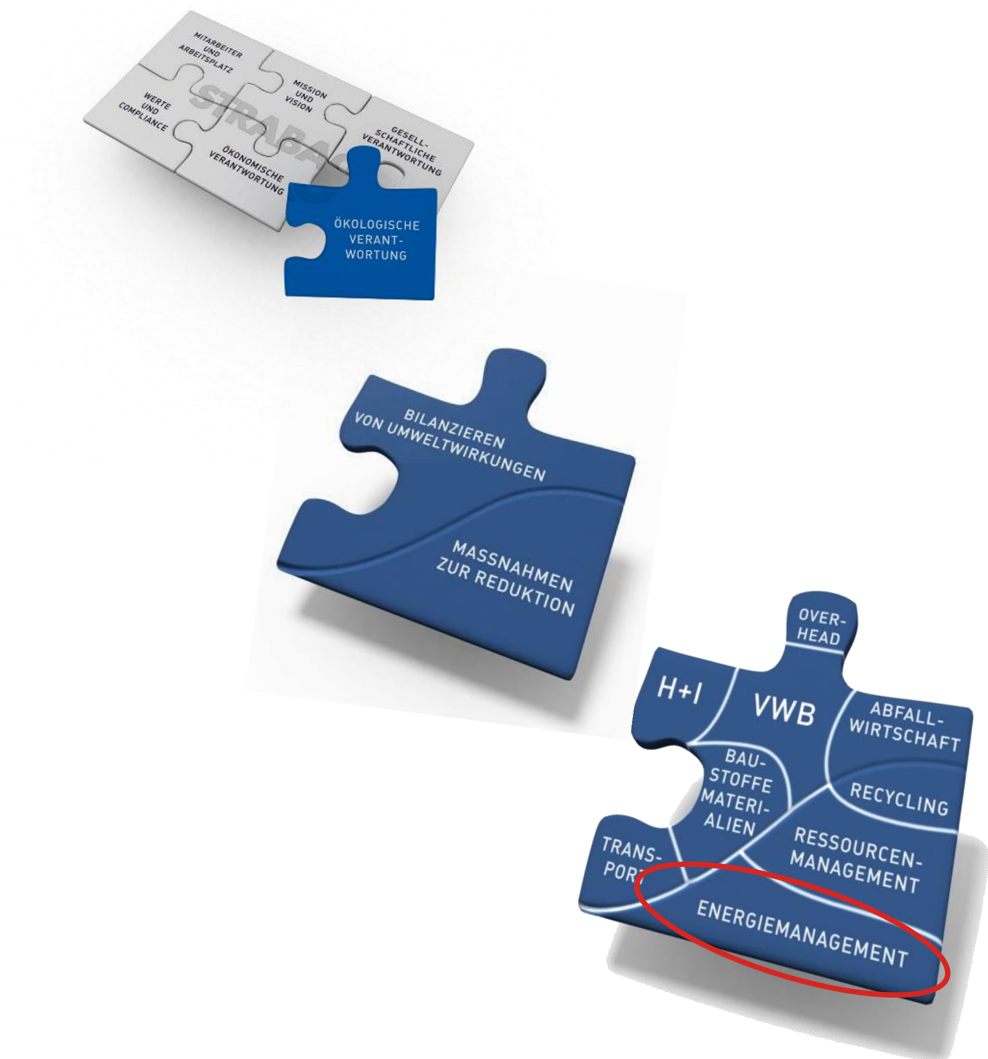
STATUS EM + CARBON MANAGEMENT BEI STRABAG

ENERGIEPOLITIK INNERHALB DER GESAMTSTRATEGIE



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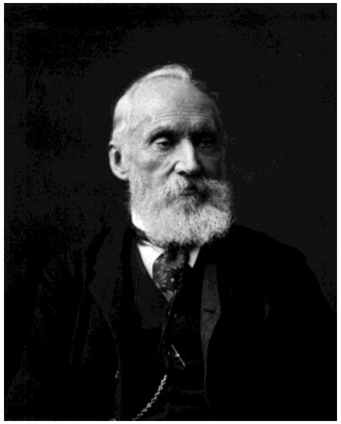
DATENERFASSUNG

IT’S THE DATA, …



”IF YOU CAN NOT MEASURE IT,

YOU CAN NOT IMPROVE IT.“

Lord Kelvin, 1824 – 1907

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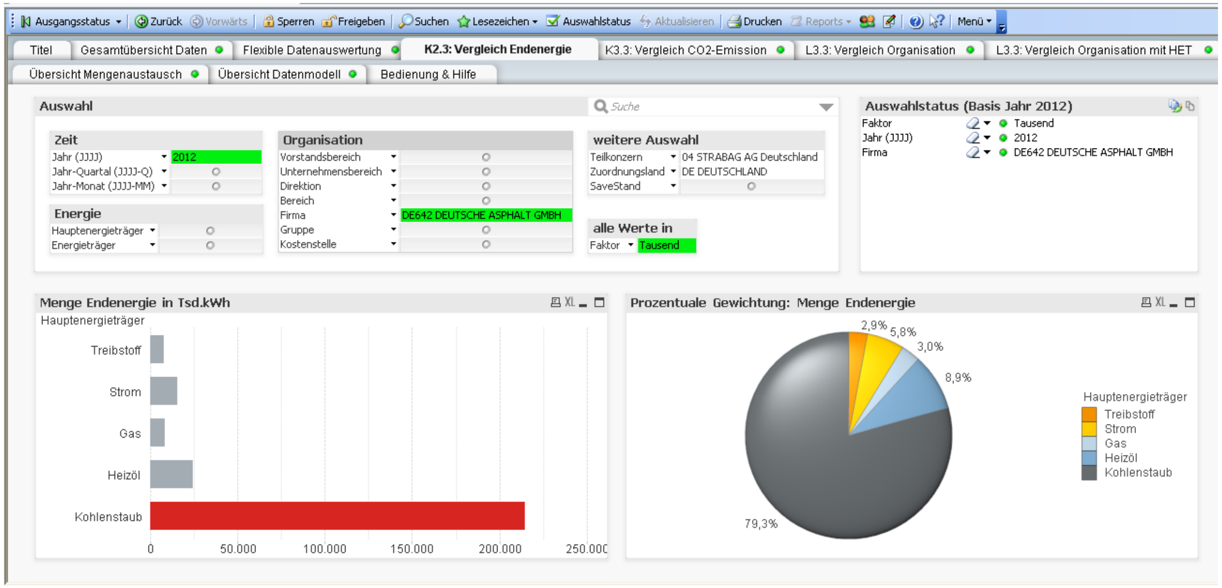
DATENVERARBEITUNG IM ENERGIE-CONTROLLING



ERGEBNIS:

ABLEITUNG BRANCHENBEZOGENER ENERGIEKENNZAHLEN

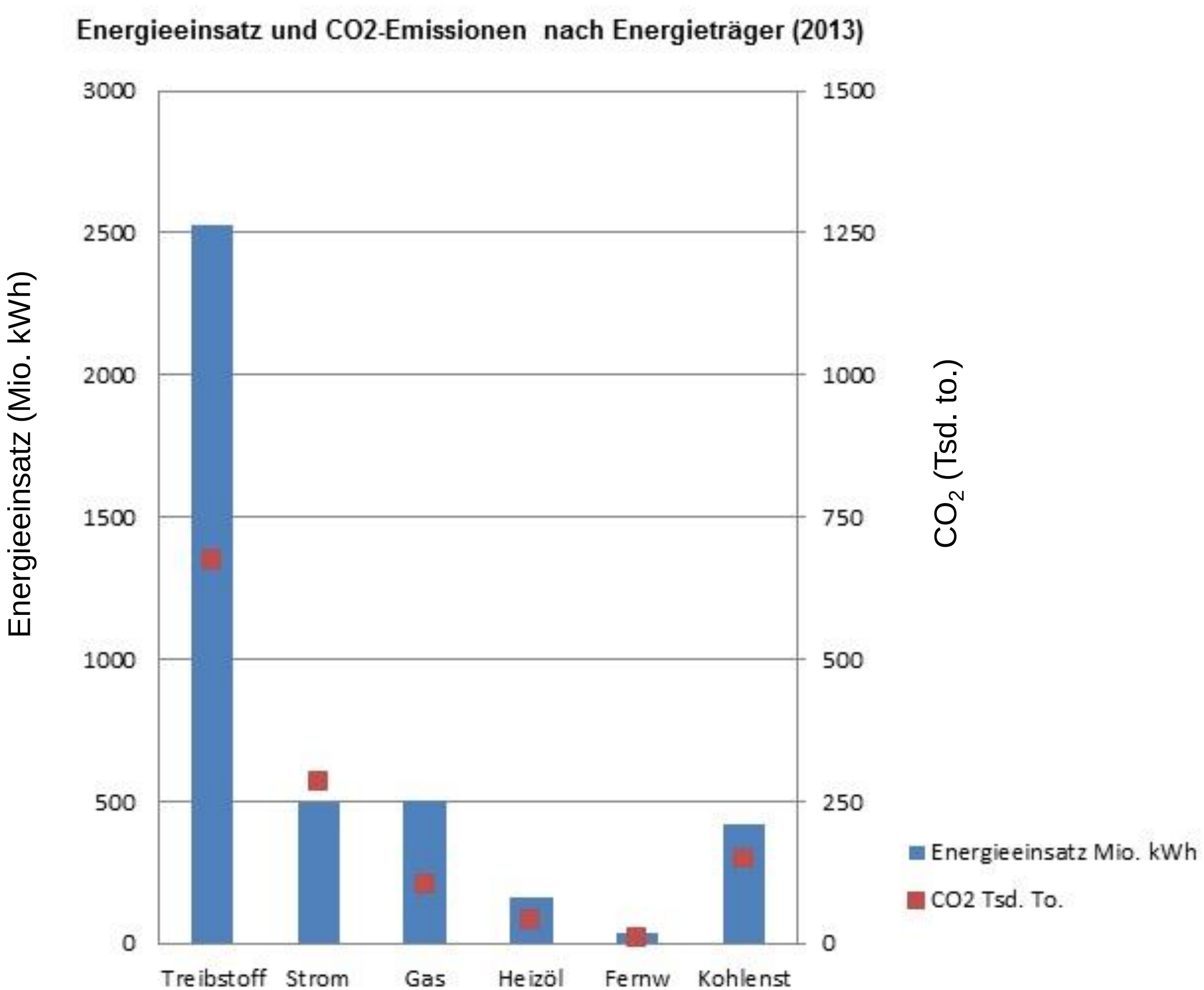
$$\frac{g\ CO_2}{Leistung\ in\ €}$$

$$\frac{Energiekosten}{Leistung\ in\ €}$$

$$\frac{Heizwert\ kWh}{Leistung\ in\ €}$$

STRABAG TEAMS WORK

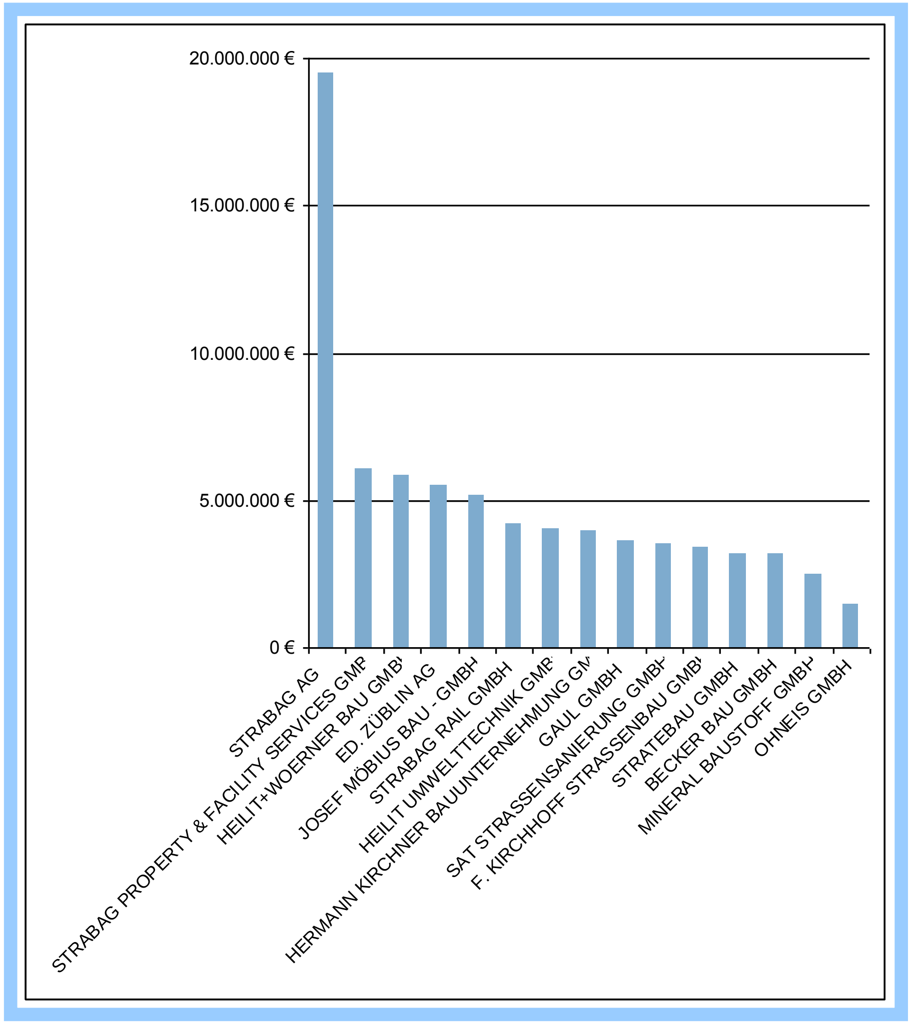
ENERGIETRÄGER IM GESAMTVERBRAUCH



Aufteilung des Energieträgereinsatzes im Konzern

STRABAG TEAMS WORK

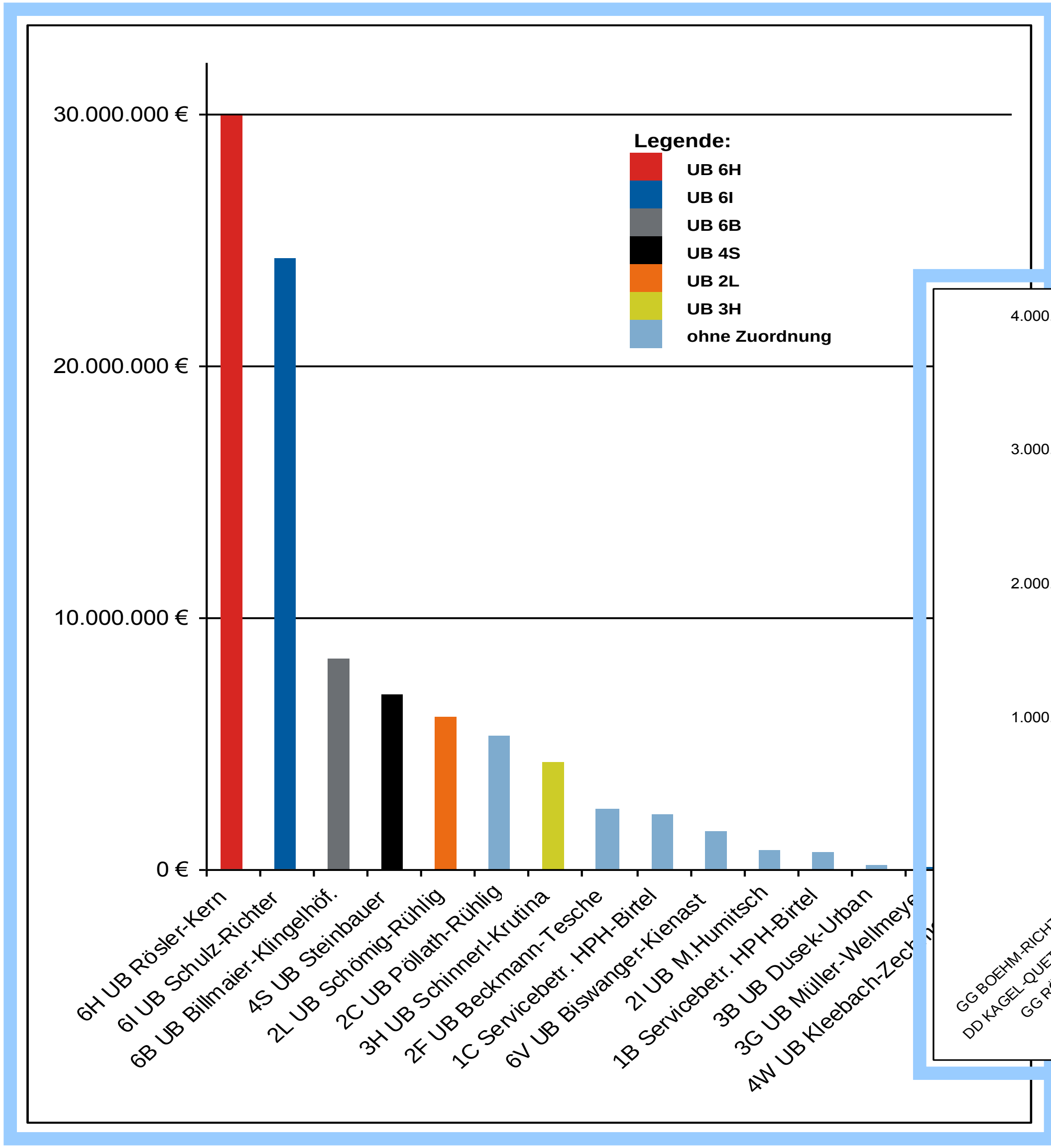
ANALYSE DER VERBRAUCHSSTRÖME



TREIBSTOFFVERBRAUCH NACH TOCHTERFIRMEN – TOP 15

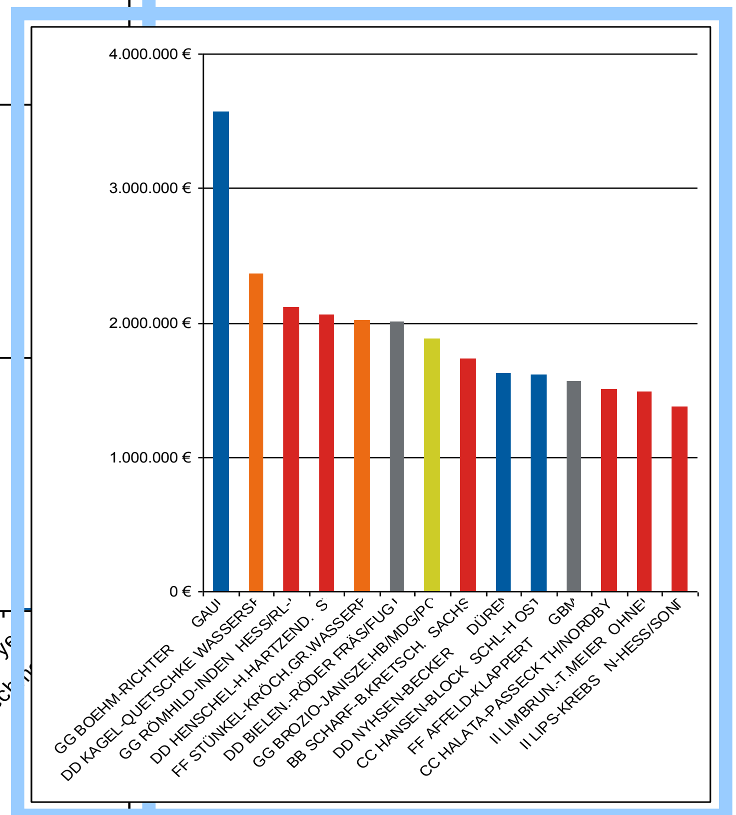
STRABAG TEAMS WORK

ZUORDNUNG VON BAUSTELLEN UND VERBRÄUCHEN



TREIBSTOFFVERBRAUCH NACH UNTERNEHMENSBEREICHEN UND OPERATIVEN TEILBEREICHEN

(JEWEILS TOP 15)



STRABAG TEAMS WORK.

ENERGIESTROMERFASSUNG IN DER PRAXIS

$$\frac{kg\ CO_2}{to.Asphalt}$$

$$\frac{Energie\ kWh}{to.Asphalt}$$

STATIONÄRE UND MOBILE MESSUNGEN

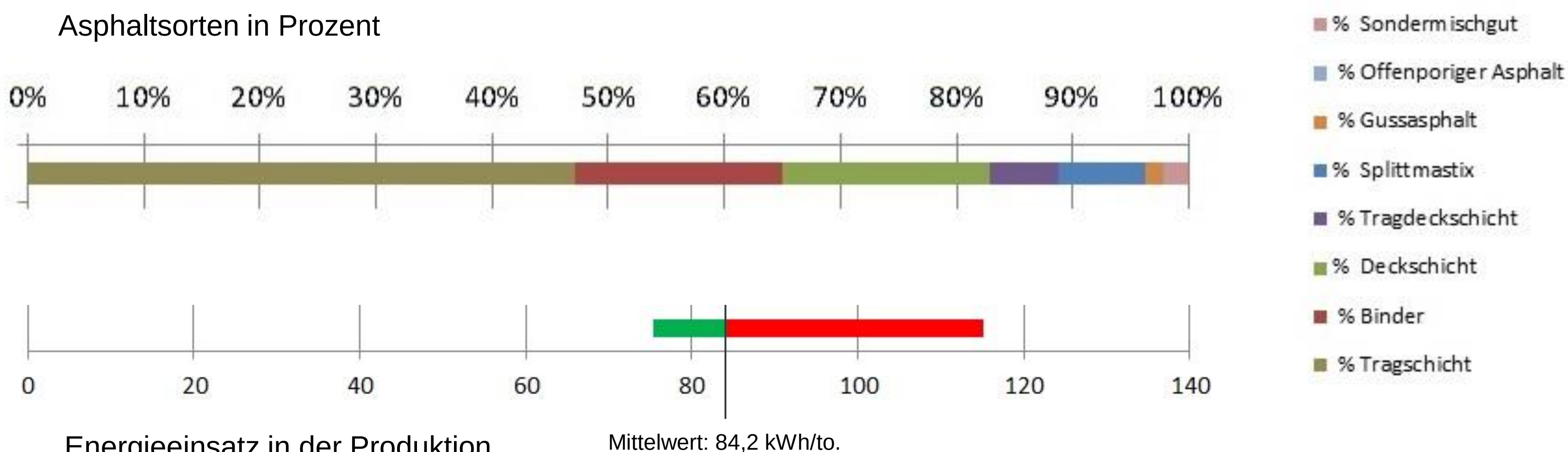
ERGEBNIS:

ABLEITUNG PRODUKTIONSBEZOGENER ENERGIEKENNZAHLEN

GELEBTES ENERGIEMANAGEMENT

ENERGIE-MONITORING UNSERER ASPHALTMISCHANLAGEN

Asphaltsorten in Prozent



Energieeinsatz in der Produktion
[kWh / to. Asphalt]

Streubereich

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WELCHE PRODUKTE BIETEN WIR
BSP: HOCH + INGBAU

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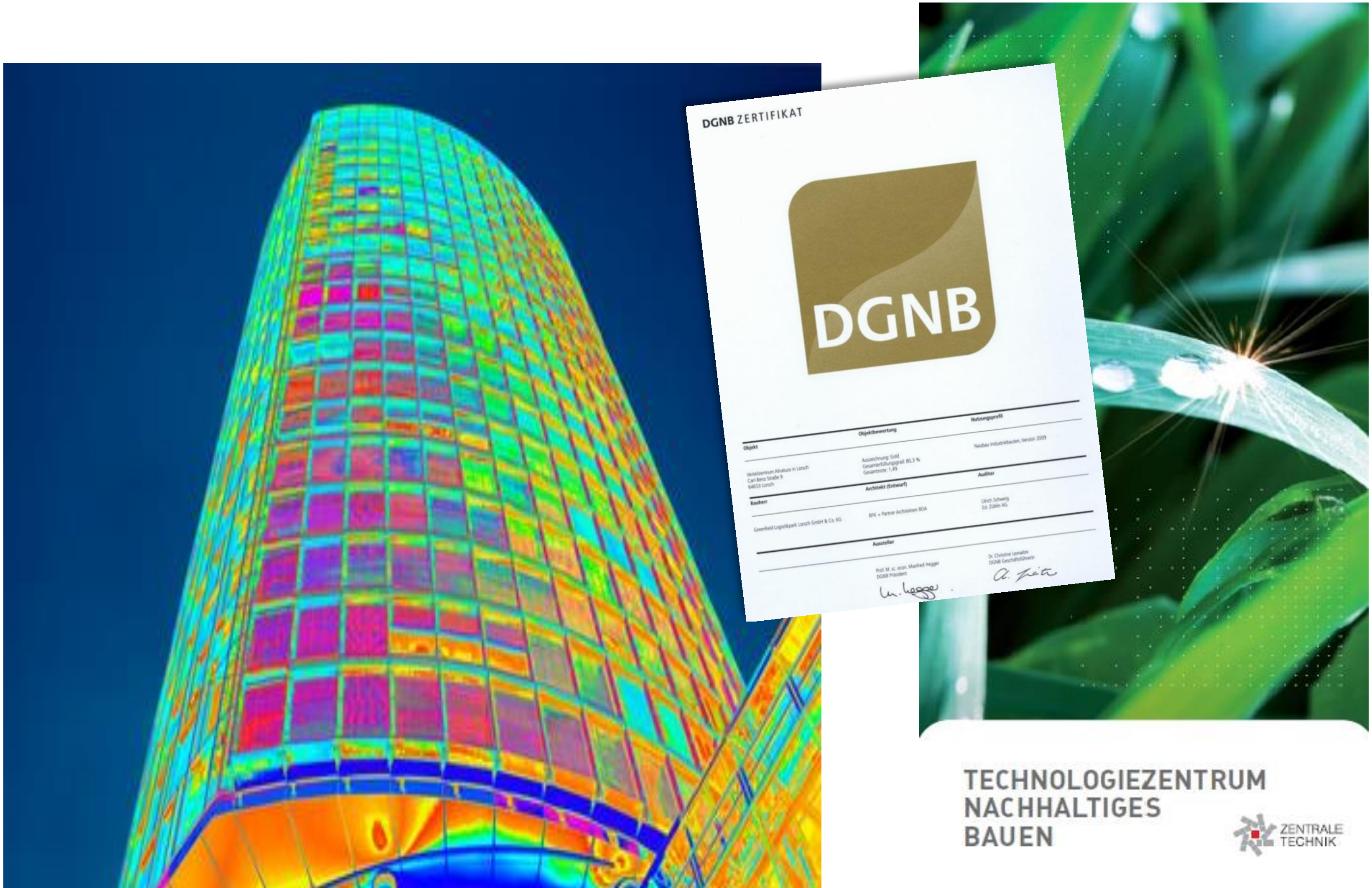
ENTWICKLUNG VON KOMPETENZEN BEI DER ENERGETISCHEN PLANUNG



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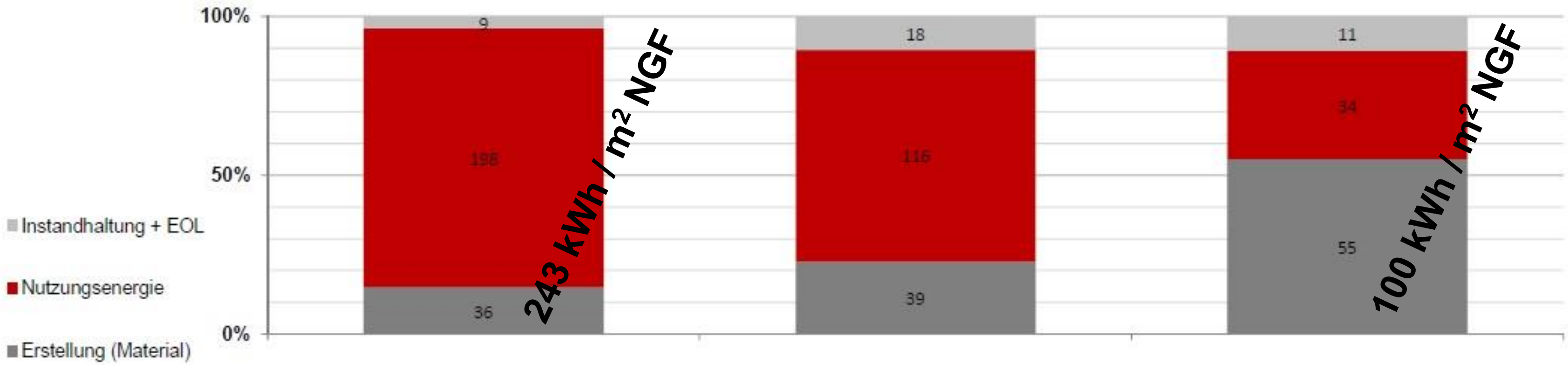
QUANTIFIZIERBARE EFFIZIENZSTEIGERUNGEN

Z-zwo
2001

Taunusstr.
2011

Z-3
2013

%-Anteil Primärenergie Gebäude nach DGNB nach 50 Jahren Gebäudelebensdauer



Werte: kWh PE_{ges} / m^2 NGF

LÖSUNGEN IM KUNDENDIALOG

QUALITÄT

ENERGIEEFFIZIENTE METHODEN

REORGANISATION

PARTNERKONZEPTE

UMWELTSCHONENDERE METHODEN

PREIS

KOSTENEINSPARUNGEN

VERBESSERUNG DER REPUTATION

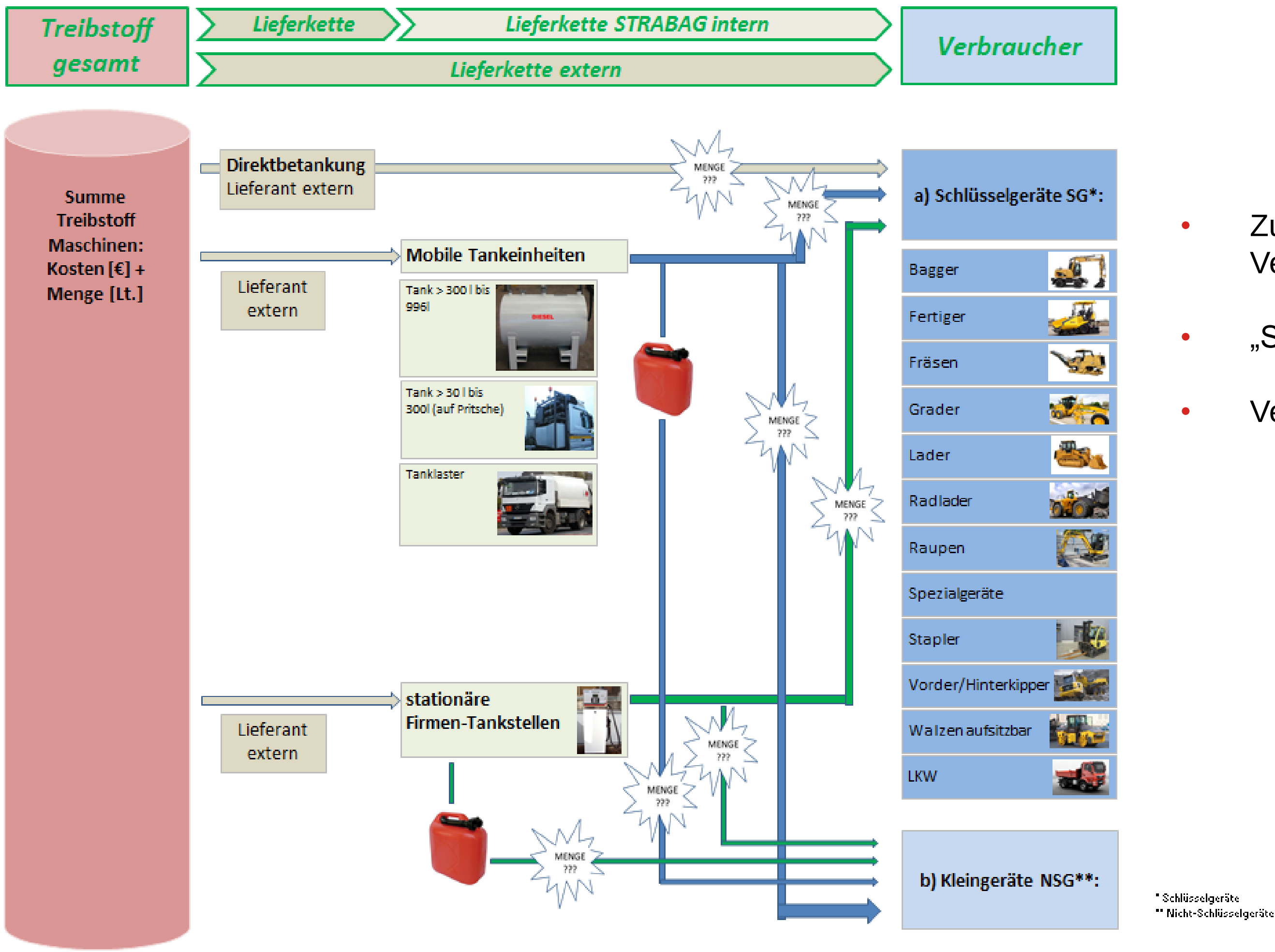
KUNDENNUTZEN

OPTIMIERUNG DER ENERGETISCHEN WERTSCHÖPFUNGSKETTE

VORTEIL

ANFORDERUNGEN DER BAUINDUSTRIE AN HERSTELLER MOBILER MASCHINEN

BEISPIEL TREIBSTOFF CONTROLLING AUF BAUSTELLEN



- Zuordnung Verbrauch zu Verbraucher schwierig
- „Schwund“ unterbinden
- Verbrauchsbewusster bedienen

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… AUS SICHT DES MASCHINENDIENSTLEISTERS

- Es gibt keine Referenzverbrauchsdaten zu Baumaschinen
  (anders bei PKW und Nfz)
- Verbrauchsdaten „von – bis“ infolge stark unterschiedlicher Einsatzfelder
  (loser Sand bis harter Fels)
- Telematikanwendungen
  (ein erster Ansatz, aber …. ?)
- Erfassung / Dokumentation von Lastprofilen und Einsatzfeldern unumgänglich
- Gem. gesetzlicher Grundlagen verpflichtet zu messen, zu dokumentieren, zu vergleichen, zu reduzieren, …

→ die Bauindustrie kann das alleine nicht !
→ techn. Voraussetzungen seitens der Baumaschinenhersteller zwingend erforderlich

STRABAG TEAMS WORK.

Potential improvements in efficiency

Viewpoint of construction and road building machinery manufacturers

Dr. Wolfgang Burget, Liebherr - EMtec GmbH

Dr. Martin Göbel, Wirtgen GmbH

Efficiency of Mobile Machines and their Applications, Symposium, Braunschweig

WIRTGEN GROUP COMPANY STRUCTURE

WIRTGEN GROUP

Brand Headquarters in Germany

- WIRTGEN GROUP – Wirtgen
- WIRTGEN GROUP – VÖGELE
- WIRTGEN GROUP – HAMM
- WIRTGEN GROUP – Kleemann
- WIRTGEN GROUP – BENNINGHOVEN

International production facilities

- WIRTGEN GROUP – CIBER
- WIRTGEN GROUP – WIRTGEN CHINA
- WIRTGEN GROUP – WIRTGEN INDIA

Sales and service companies

WIRTGEN GROUP – VERTRIEBS- UND SERVICEGESELLSCHAFTEN

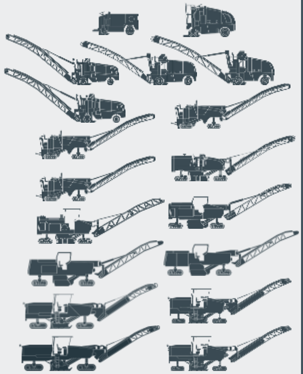
55 own sales and service companies and over 150 dealers worldwide

WIRTGEN: WORLD MARKET LEADER FOR COLD MILLING MACHINES, COLD RECYCLERS, SOIL STABILIZERS AND SURFACE MINERS

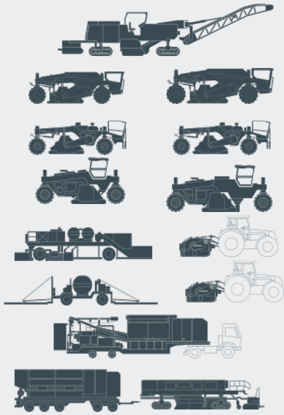
Employees: 1,400

MACHINERY AND PROCESSES FOR ROAD CONSTRUCTION AND REHABILITATION

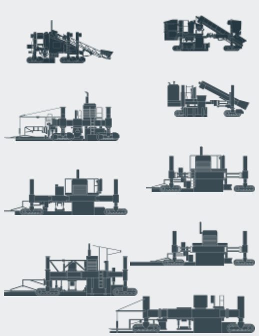
Cold milling machines



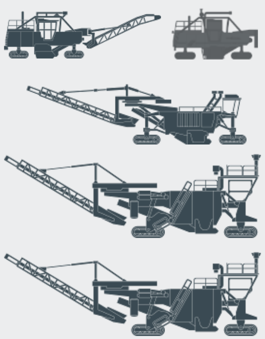
Recyclers



Slipform pavers



Surface Miners



Status: January 2015

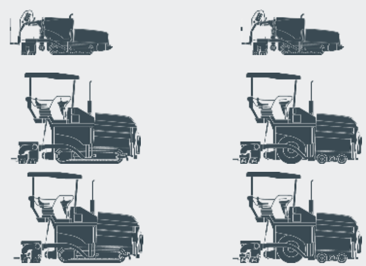
VÖGELE:
WORLDWIDE LEADING MANUFACTURER FOR PAVERS

Employees: 850

Status: January 2015

INNOVATIVE SOLUTIONS FOR PAVING ASPHALT AND SUB-BASE MATERIALS

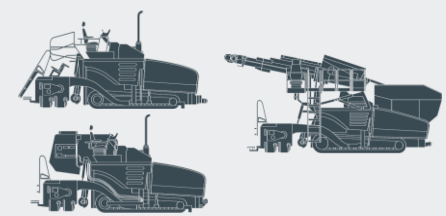
SUPER Series / Mini and Compact Class



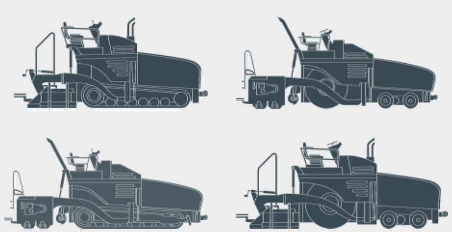
SUPER Series / Universal Class

SUPER Series / Highway Class

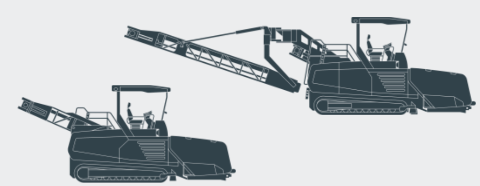
SUPER Series / Special Class



VISION Series



PowerFeeders



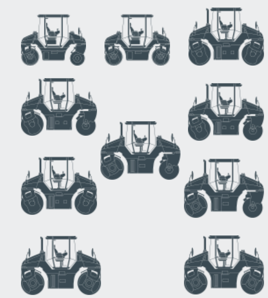
HAMM:
GLOBAL MARKET LEADER FOR ASPHALT COMPACTORS

Employees: 750

FIRST-CLASS TECHNOLOGY FOR SOIL AND ASPHALT COMPACTION

Tandem rollers: HD

Tandem rollers: DV



Compactors

Static rollers

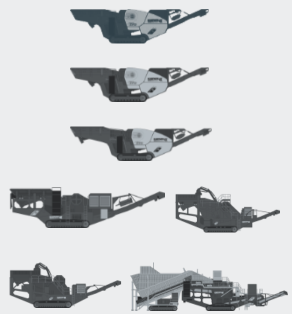
KLEEMANN: TECHNOLOGY LEADER FOR MOBILE CRUSHERS

Employees: 400

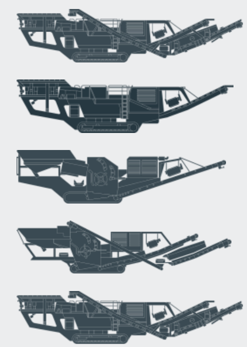
Status: January 2015

PLANT TECHNOLOGY FOR THE PROCESSING OF MINERALS AND FOR RECYCLING PURPOSES

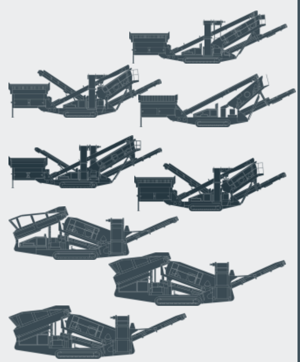
MOBICAT:
Mobile jaw crushers



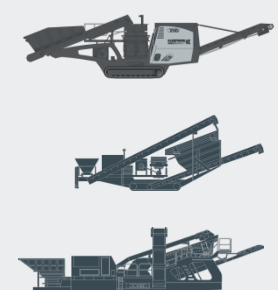
MOBIREX:
Mobile impact crushers



MOBISCREEN:
Mobile screens



MOBICONE/MOBIFOX:
Secondary crushing plants



BENNINGHOVEN: SPECIALIST FOR THE PRODUCTION OF ASPHALT MIXING PLANTS

Employees: 600

BENNINGHOVEN

THE RIGHT ASPHALT MIXING PLANT FOR EVERY KIND OF MIX

Container Asphalt Mixing Plants Type „ECO“

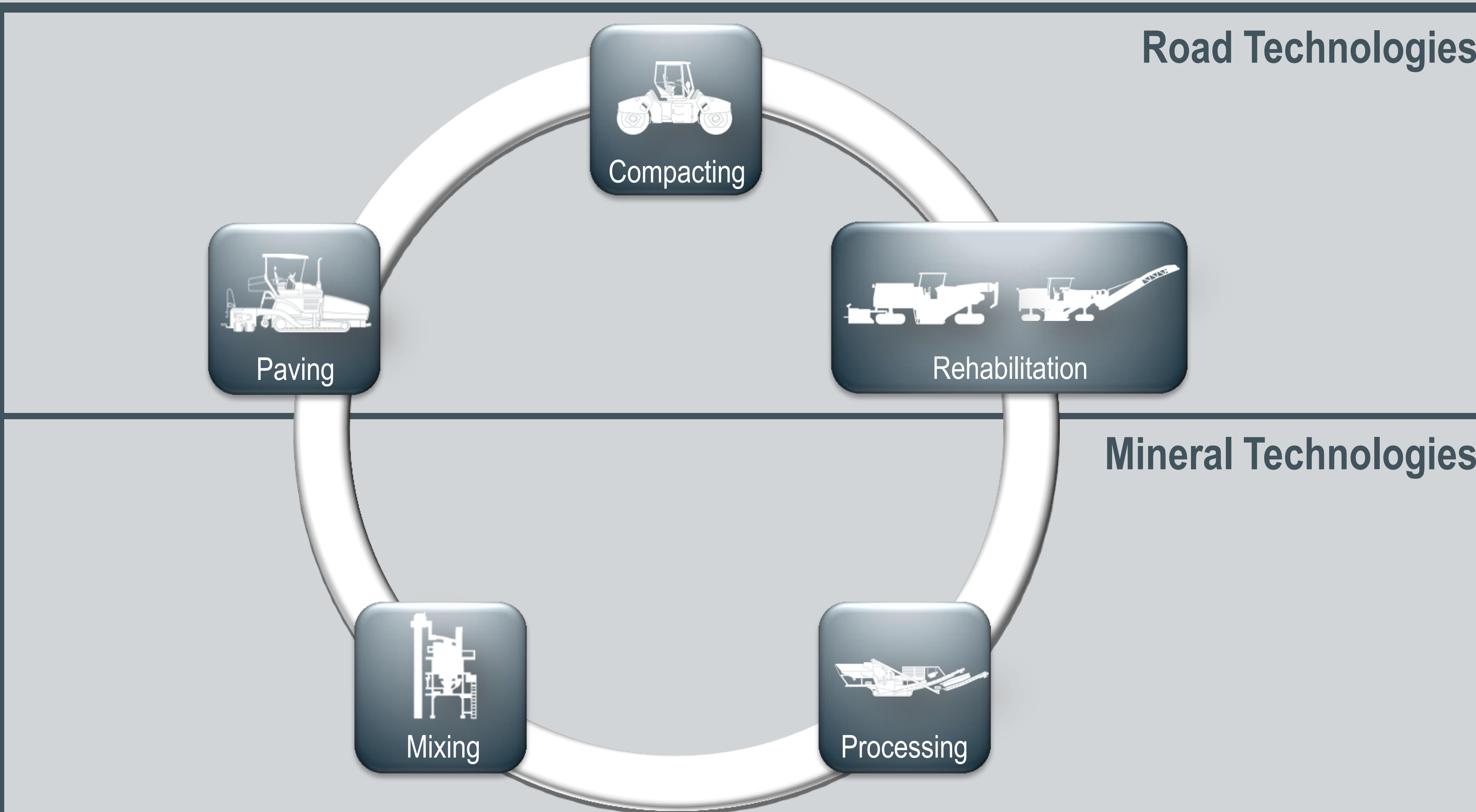
Transportable Asphalt Mixing Plants Type „TBA“

Mobile Asphalt Mixing Plants Type „MBA“

Stationary Aspalt Mixing Plants Type „BA“

Status: January 2015

THE WIRTGEN GROUP CONCEPT



EVOLVING FOCUS OF INNOVATIONS

WIRTGEN GROUP

Mechanisation | **Automation** | **Process innovation**

Innovations

ENERGY EFFICIENCY AS AN OBJECTIVE FOR MOBILE MACHINE MANUFACTURERS

WIRTGEN GROUP

Energy efficiency as a social objective

- Cost of energy
- Green House Gas emissions
- Consumption of limited resources
- …

Energy efficiency as customer added value

- Operating cost
- Sustainability (carbon footprint, environmental targets)

Energy/GHG efficiency is already an inherent objective for mobile machine manufacturers

- Social responsibility and environmental targets
- Customer demands and market success

Construction machinery

Wide range of applications

Building construction machinery and equipment

LIEBHERR

Construction machinery

Wide range of applications

Building construction machinery
and equipment

Material handling

LIEBHERR

Construction machinery

Wide range of applications

Building construction machinery and equipment

Material handling

Forestry machinery

Construction machinery

Wide range of applications

Building construction machinery and equipment

Material handling

Forestry machinery

Earth moving machinery

Construction machinery

Wide range of applications

Building construction machinery and equipment

Material handling

Forestry machinery

Earth moving machinery

Road building machinery

LIEBHERR

Construction machinery

Wide range of applications

Building construction machinery and equipment  

Material handling  

Forestry machinery  

Earth moving machinery  

Road building machinery  

Mineral technologies machinery

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Construction machinery

Wide range of applications

- Thousands of machine types
- Small annual quantities

Building construction machinery and equipment


Material handling


Forestry machinery


Earth moving machinery


Road building machinery


Mineral technologies machinery


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The market driven approach

The European Mobile Machinery Industry is committed to CO_2 reduction!

BUT: **- Any approach should work in a wide sector of diversified applications**
- Individual solutions have to be taken into consideration

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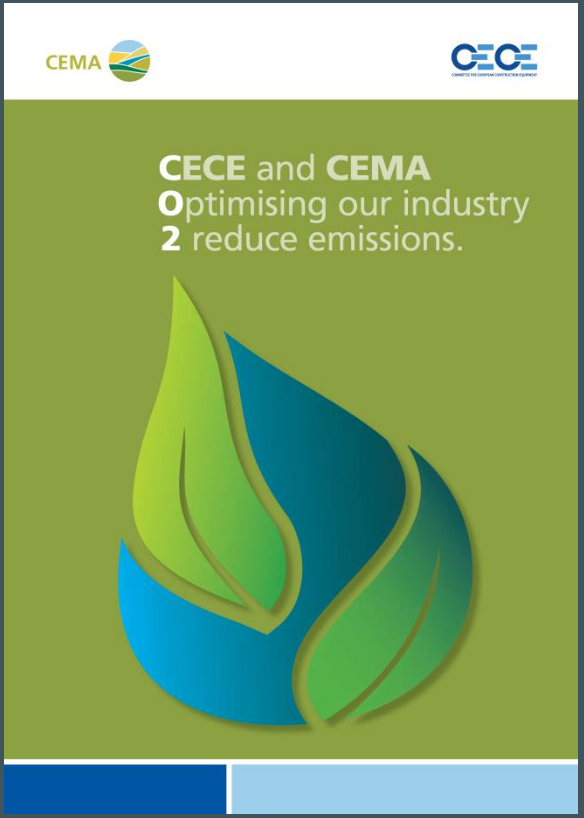
CECE/CEMA CO2 SUCCESS STORIES

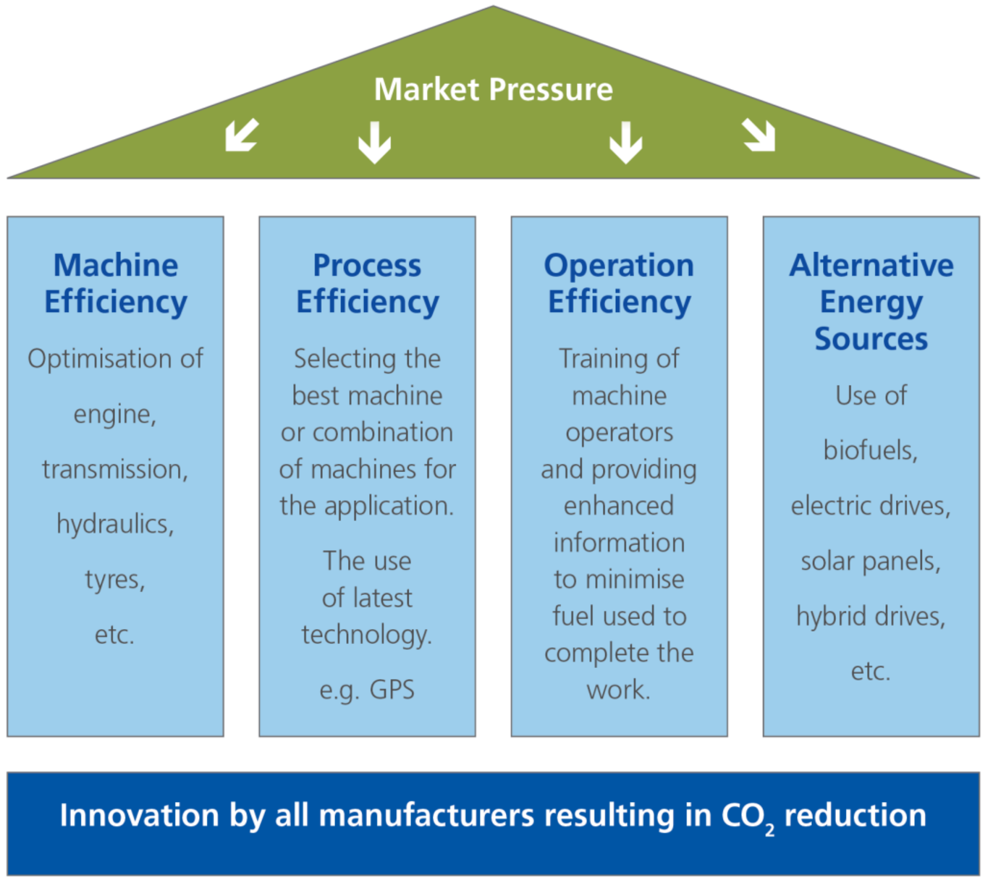
- CECE
  Committee for European Construction Equipment
  - 1.200 companies
  - 130.000 direct employees
  - 25 billion Euro sales
- CEMA
  European Agricultural Machinery
  - 4.500 companies
  - 135. direct employees
  - 28 billion Euro sales



http://www.cece.eu/publications/brochures/
-> CECE/CEMA CO2 success stories

Source: www.cece.eu, www.cema-agri.org

CECE - CEMA: 4 PILLARS APPROACH



Source: Publication CECE/CEMA CO2 success stories, http://www.cece.eu/publications/brochures/

WIRTGEN: DUAL-ENGINE CONCEPT FOR LARGE MILLING MACHINES

Machine efficiency

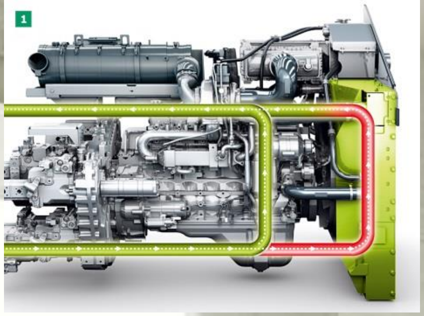
WIRTGEN GROUP

- Little power needed: only one engine is used
- Full power needed: second engine starts automatically
- Eco-mode: energy efficient operation even at full load
- Up to 25% lower fuel consumption possible

VÖGELE: „ECOPLUS“ TECHNOLOGY

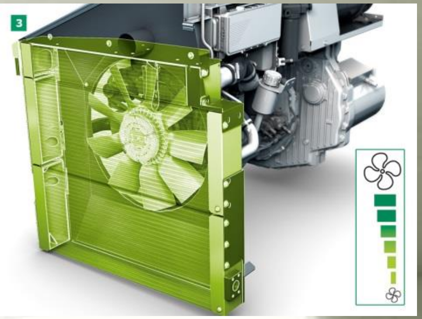
Machine efficiency

- Controlled hydraulic oil temperature circuit

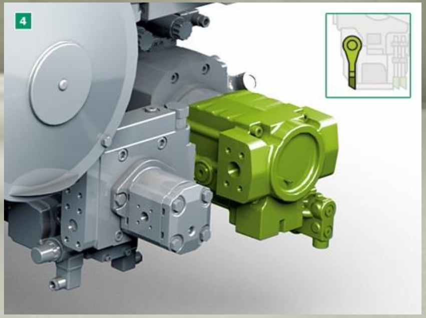


- Splitter gearbox

- Variable-speed fan



- Energy-optimized tamper drive



WIRTGEN GROUP: IN-PLACE COLD RECYCLING OF ASPHALT PAVEMENTS

Process efficiency

Conventional „Mill & Fill“	In-place cold recycling
Remove material	Remove material
Transport material from the site	
Dispose old material	
Produce new material	Recycle material in-place
Transport material to the site	
Paving	Paving
Compacting	Compacting

- Ecological alternative to the conventional “mill & fill” process
  - Save transportation of material to and from the site
  - Save production of new material

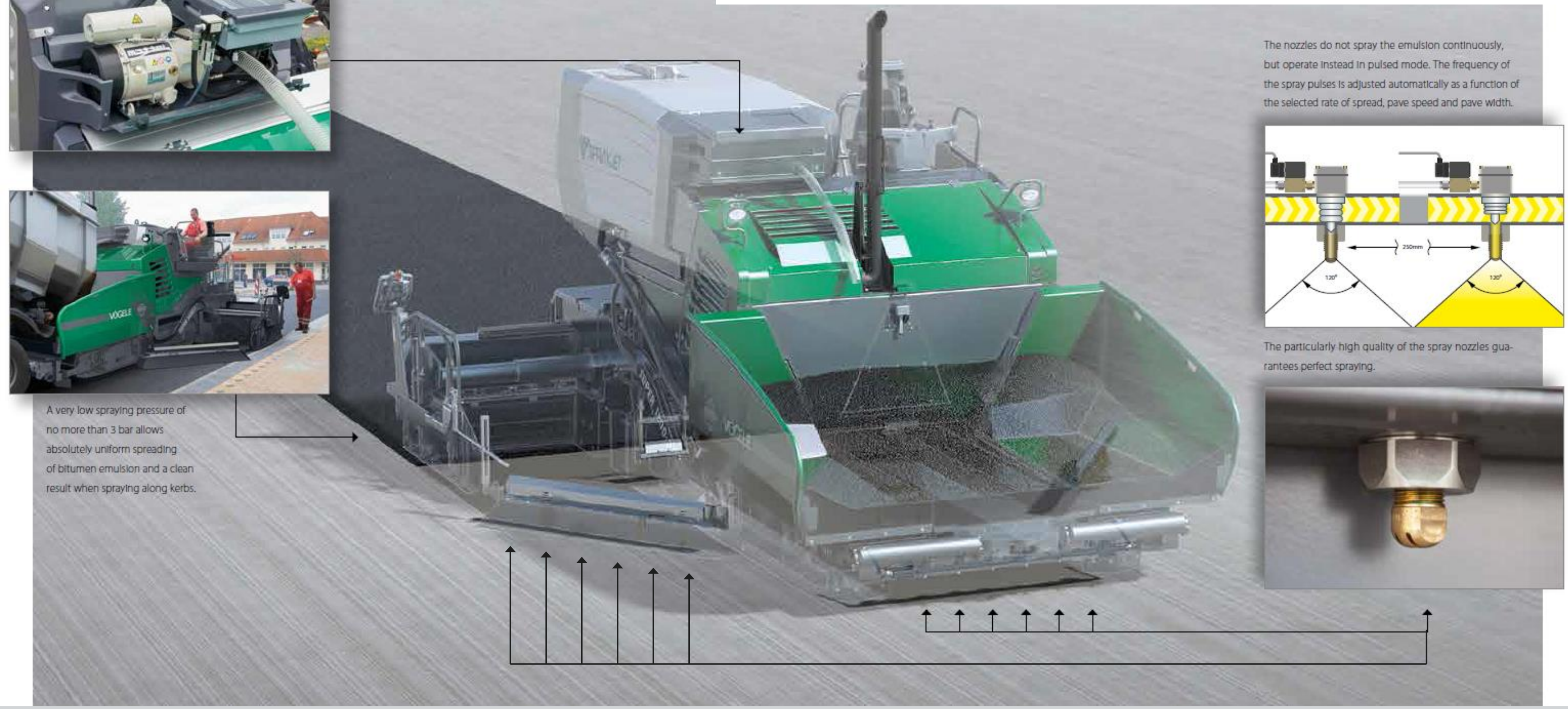
Wirtgen Group cold recycling at a job site, USA

VÖGELE: PAVING THIN WEARING COURSES WITH SPRAYJET TECHNOLOGY

Process efficiency

WIRTGEN GROUP

- SprayJet technology allows spraying and paving in one pass
- Thin layers save up to 50 % on paving material
- Excellent bond between layers ensures a long service life



HAMM: HCQ-NAVIGATOR PREMIUM

Operation efficiency

WIRTGEN GROUP

HAMM Compaction Quality

- Position of all rollers on the job site is measured via DGPS
- System suggests optimal path to the machine operator
- Increase efficiency by avoiding over-compaction of areas
- Improve compaction quality

WIRTGEN GROUP: MACHINE OPERATOR TRAINING

Operation efficiency

- Optimal machine operation can only be achieved by well trained operators
  - Correct setup-up of process parameter
  - Avoid unnecessary operations
  - Machine maintenance, i.e. engine filters, wear parts replacement
  - …

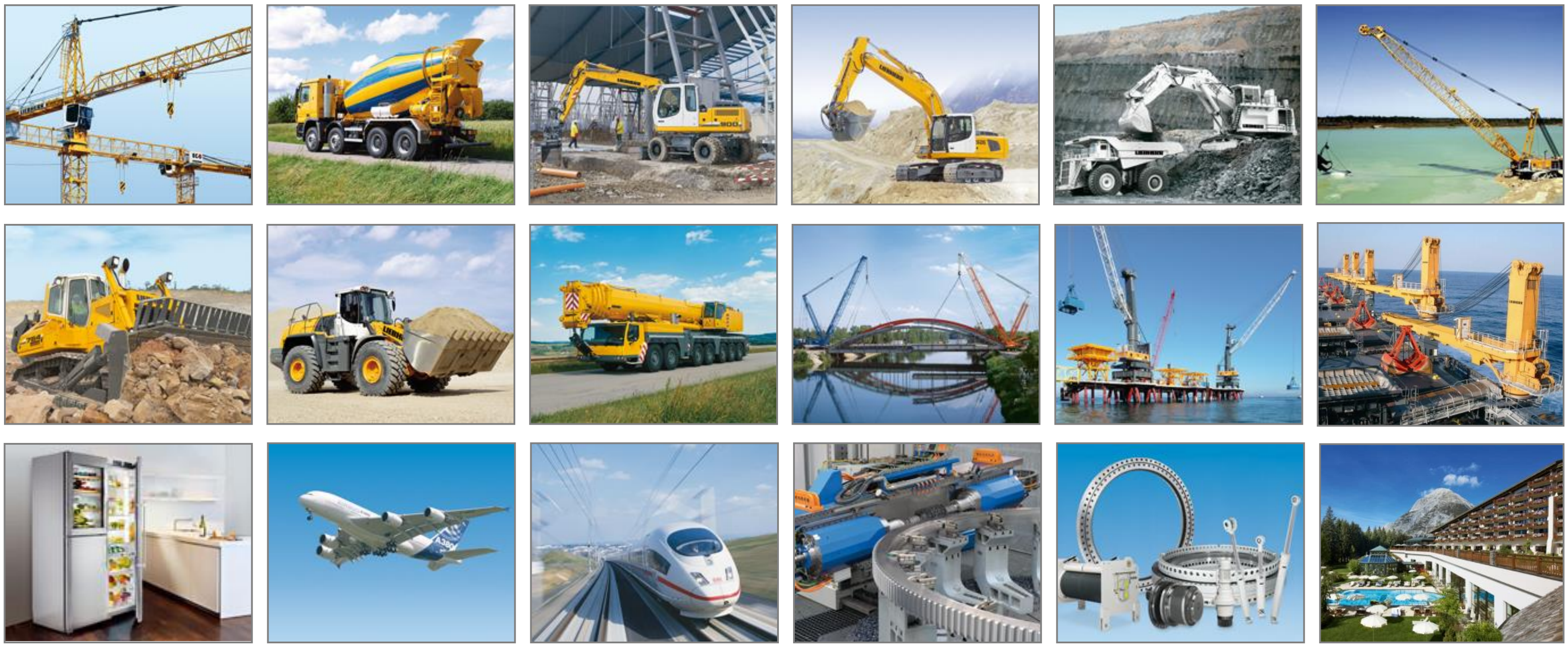
KLEEMANN: DIESEL-ELECTRIC DRIVE

Alternative Energy Sources

WIRTGEN GROUP

- Power supply via electric power grid or diesel generator alternatively
- Electric drive technology for directly driven crusher, belts and pre-screen
- Electric power supply reduces CO_2 emissions significantly

Multifaceted product range



Wheel loaders

- Product range:
  - Stereoloaders
    with tipping loads of up
    to 5.7 tonnes
  - Medium large wheel loaders
    with tipping loads of up to
    9.8 tonnes
  - Large wheel loaders
    with tipping loads of up
    to 20.4 tonnes

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Crawler tractors & loaders, pipelayers & telescopic handlers

- Product range:
  - Crawler tractors
    with engine outputs of 86 to 310 kW
  - Crawler loaders
    with bucket capacities of up to 2,5 m³
  - Pipelayers
    with lifting forces of up to 91 tonnes
  - Telescopic handlers
    with lifting heights of up to 13 m

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Crawler excavators

- Operating weight from 14 to 804 tonnes
- Power outputs of up to 2,984 kW
- Areas of application:
  - Earthmoving
  - Material handling
  - Building demolition
  - Hydraulic engineering
  - Tunnelling
  - Mining

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Wheeled excavators and material handlers

- Operating weight from 11 to 127 tonnes
- Areas of application:
  - Civil engineering
  - Garden and landscape construction
  - Material and goods handling
  - Waste management

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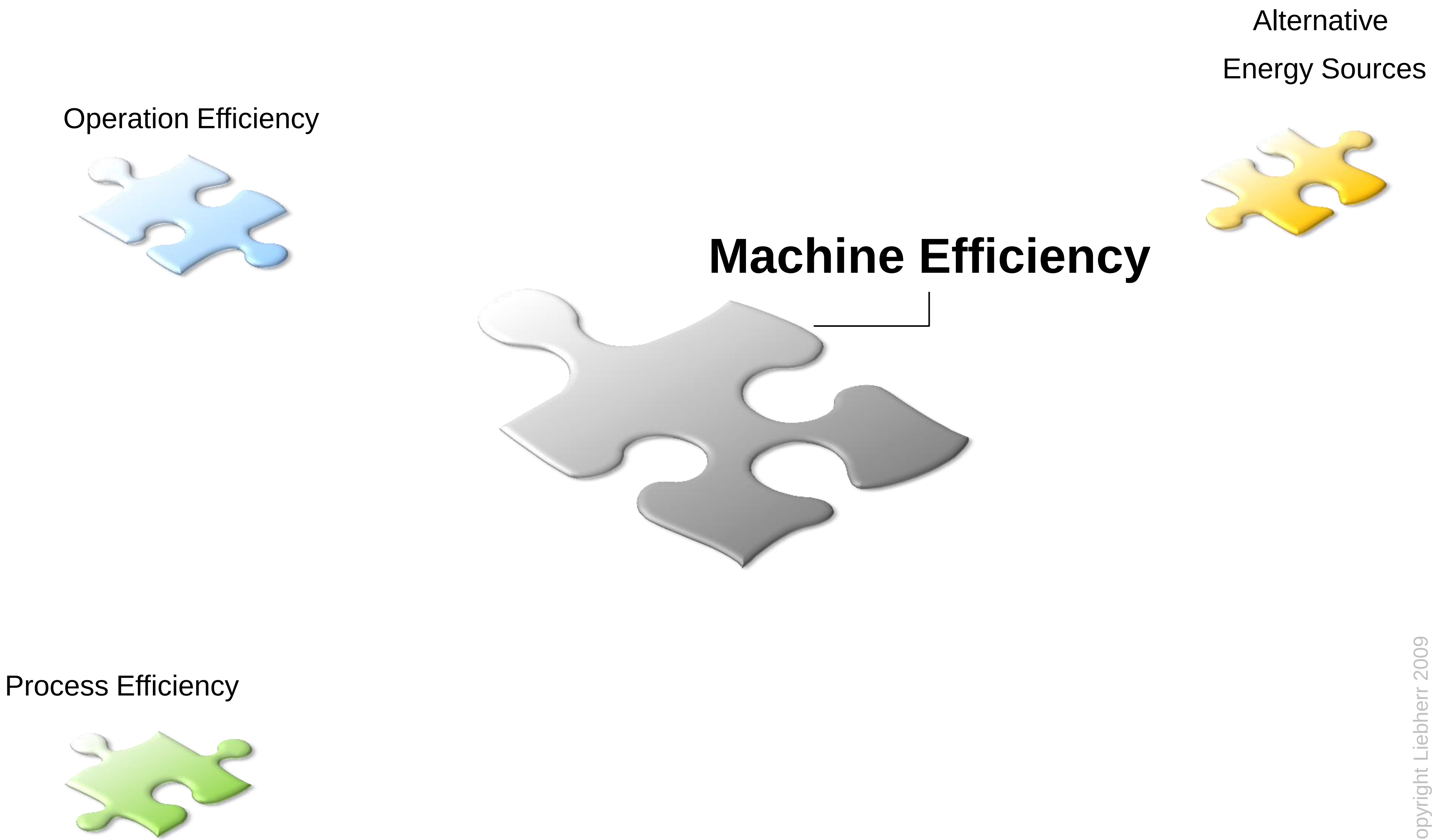
CO_2 - reduction: market driven approach



CO_2 - reduction: Machine efficiency HEX

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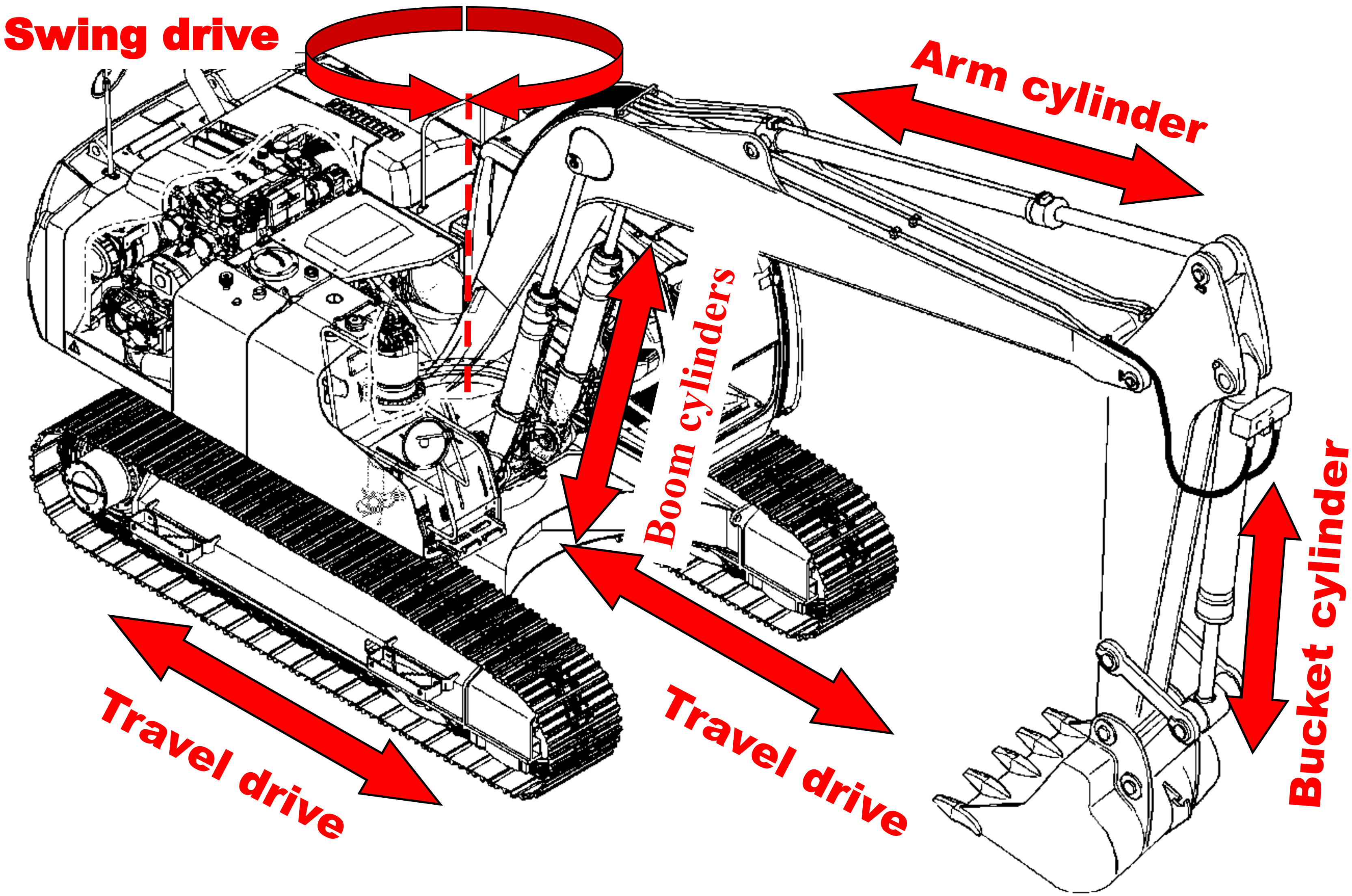
Crawler excavator – HEX drive systems



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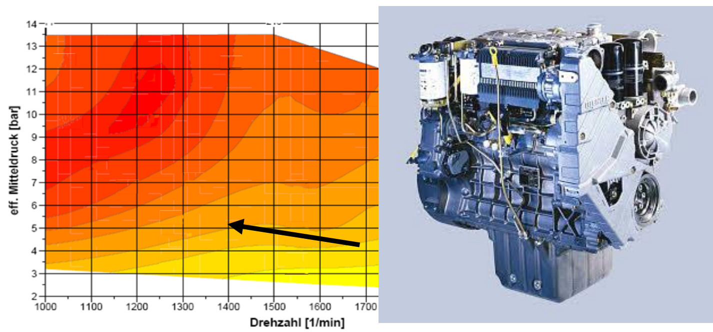
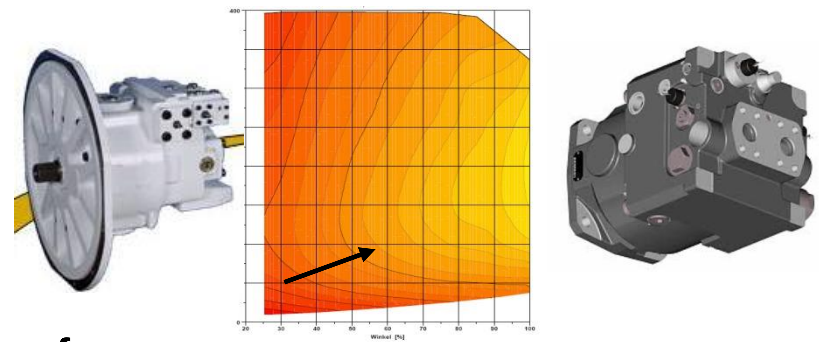
Optimized system control

System charateristics

Optimized engine speed



Optimized hydraulic pump/motor regime



Optimized system performance

Liebherr LPE

CO_2 - reduction: Machine efficiency WHL

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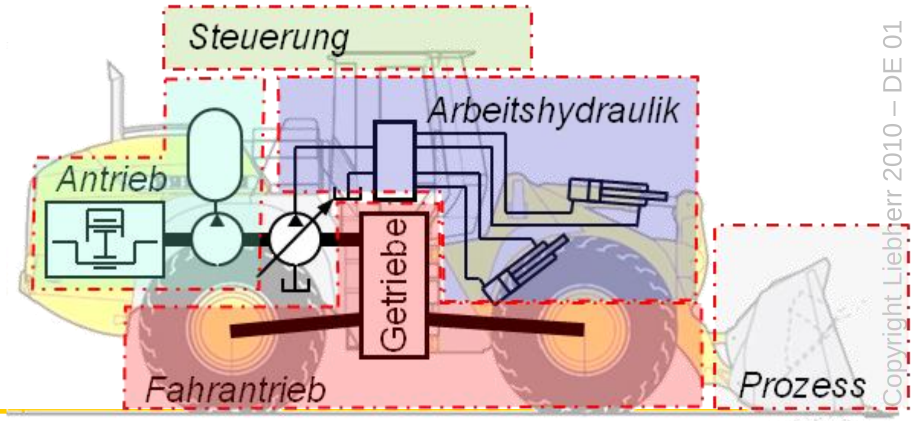
TEAM - project: „Green Wheel loader“

Demonstrator „Green Wheel Loader“

1. Design and optimization of all subsystems relevant for energy transfer
   a. Travel drive
   b. Working hydraulics
   c. Diesel - engine
2. Use of a hydraulic hybrid system to evaluate the energy recovery potential
3. Control units for subsystems
4. Control units for wheel loader system
5. Stepwise validation and field testing of the demonstrator



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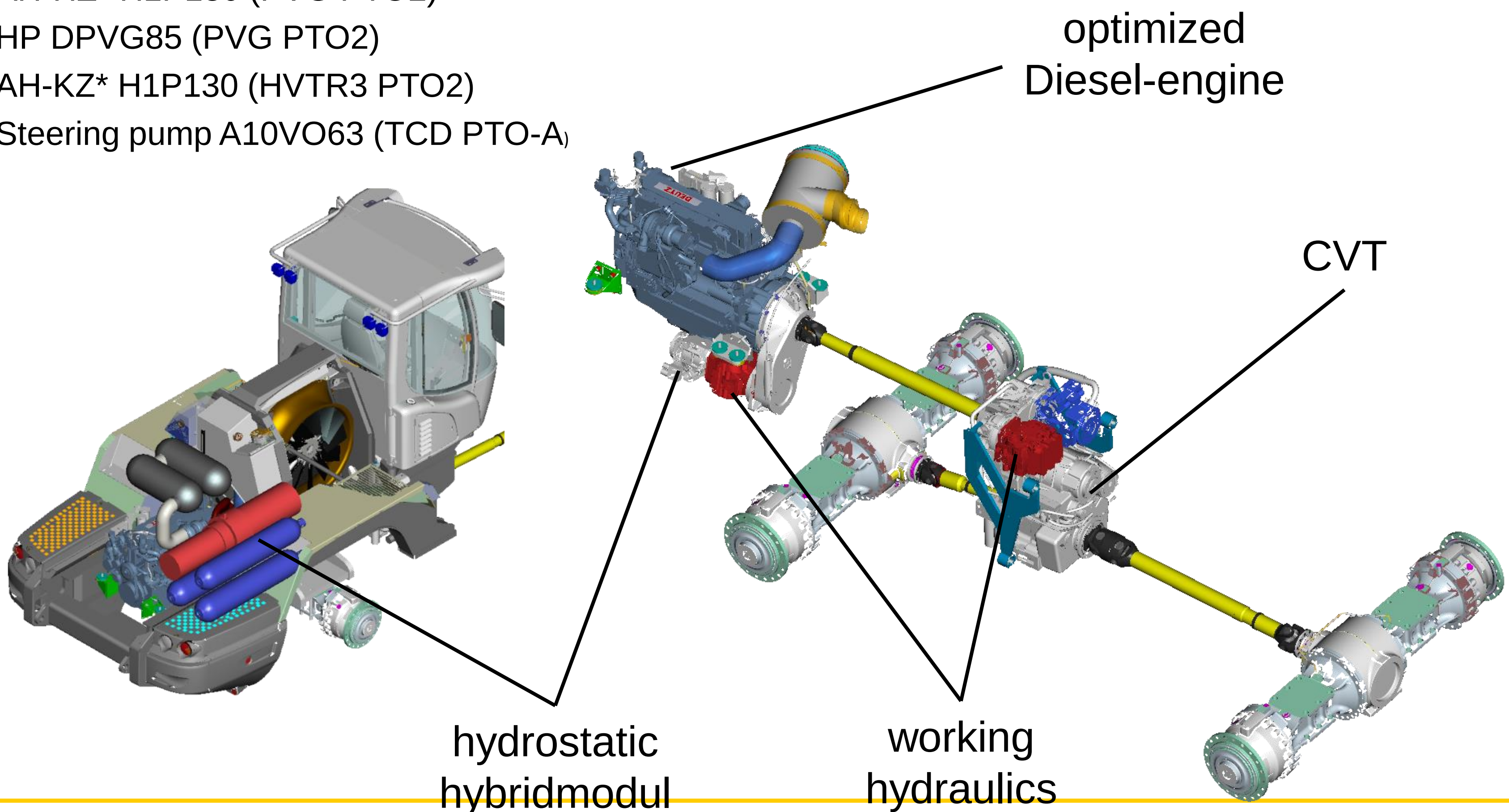
TEAM - project: „Green WHL“ - system

- Diesel TCD 7,8 L6 (Deutz)
- PVG 351 B 367 (LMB)
- AVG HVTR3 (BRR)
- AH-HZ* H1P130 (PVG PTO2)
- HP DPVG85 (PVG PTO2)
- AH-KZ* H1P130 (HVTR3 PTO2)
- Steering pump A10VO63 (TCD PTO-A)



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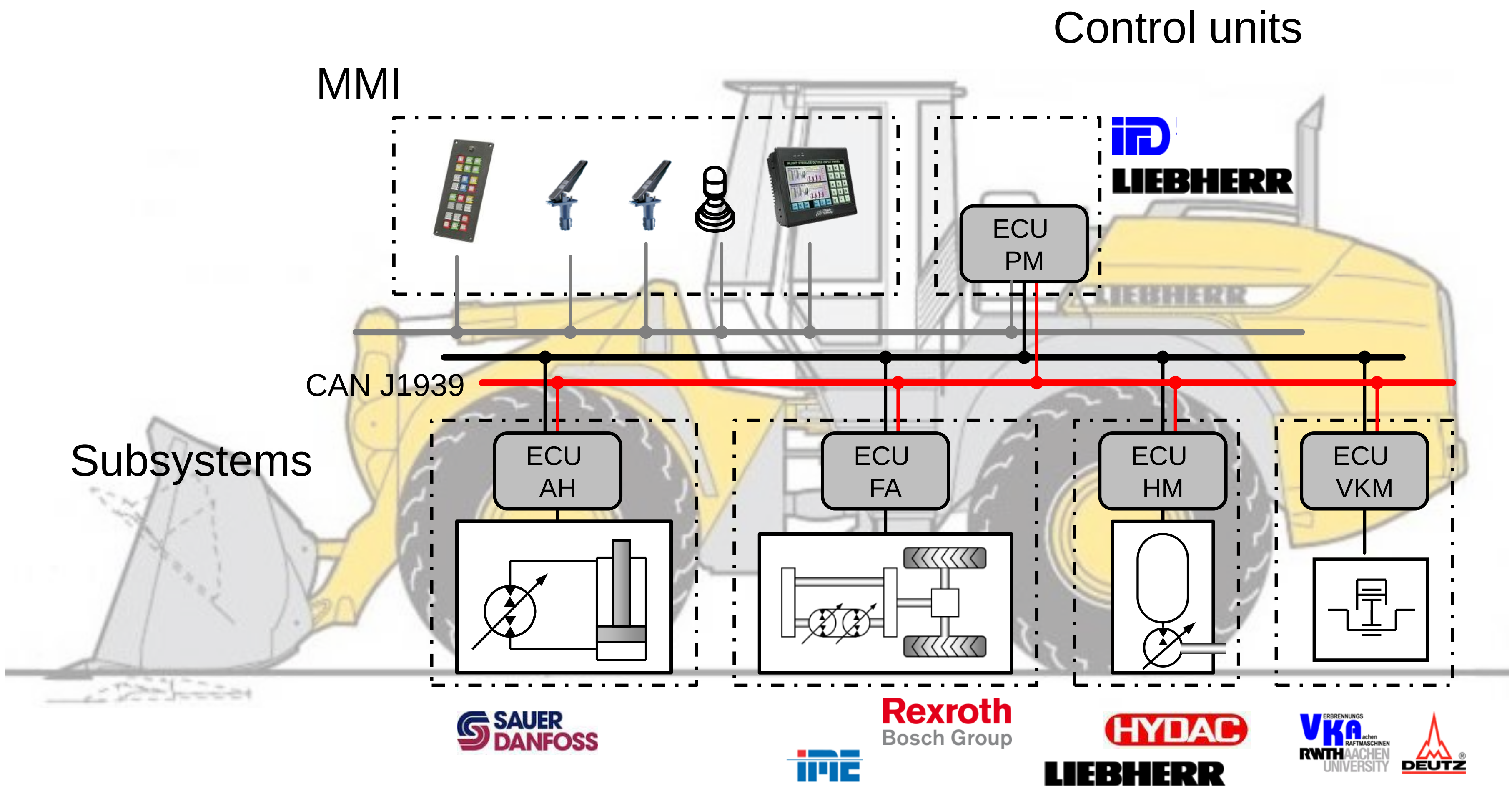
TEAM – project: „Green WHL“ – components



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CO_2-reduction: Machine efficiency dozers

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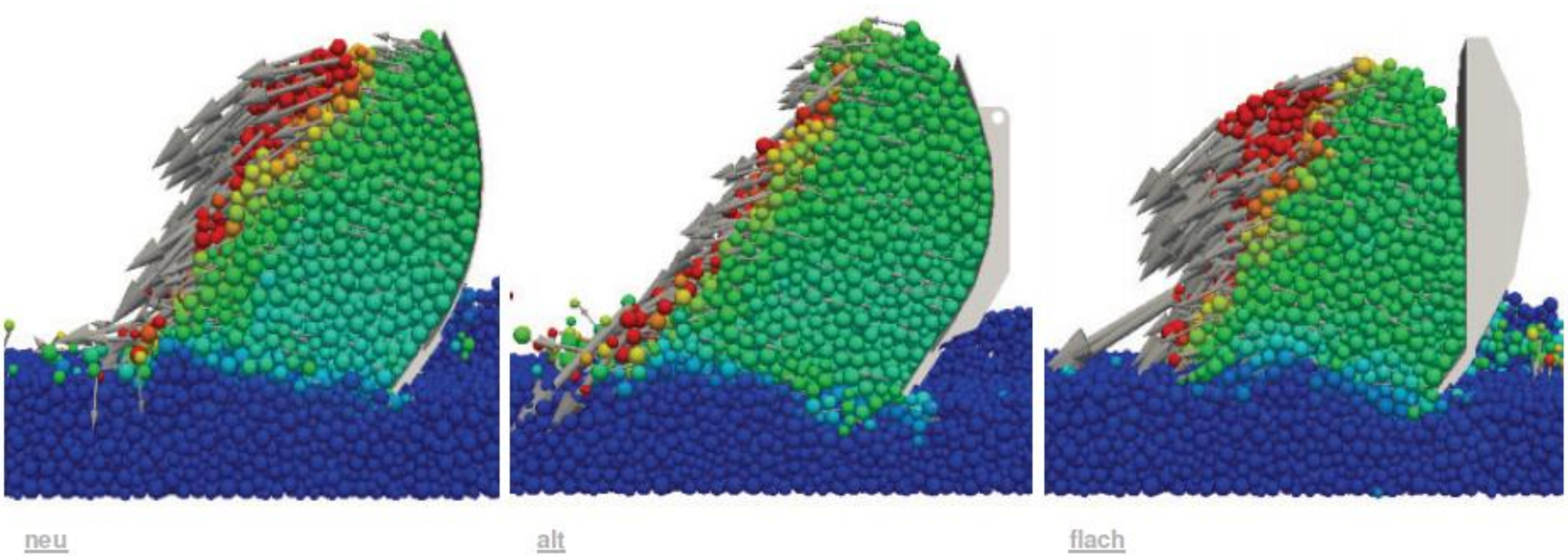
Energy efficiency for crawler dozers

Simulation of ground/ machine interaction

Optimization of pushing shield geometry



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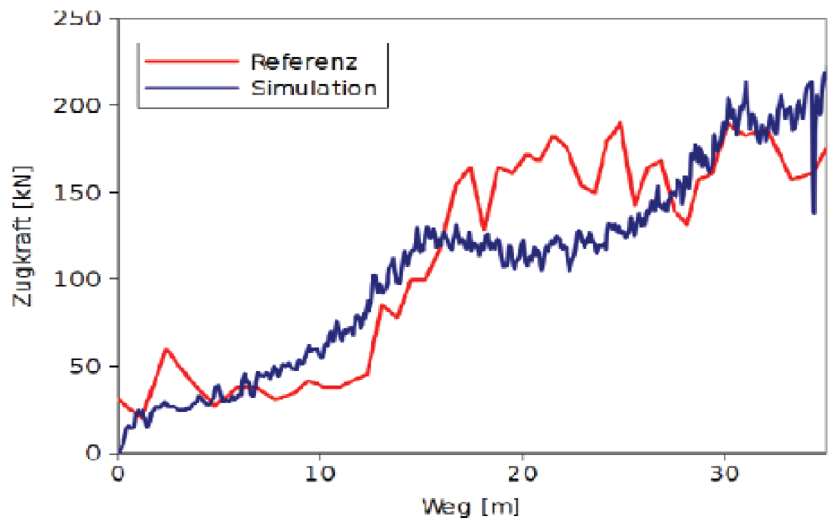
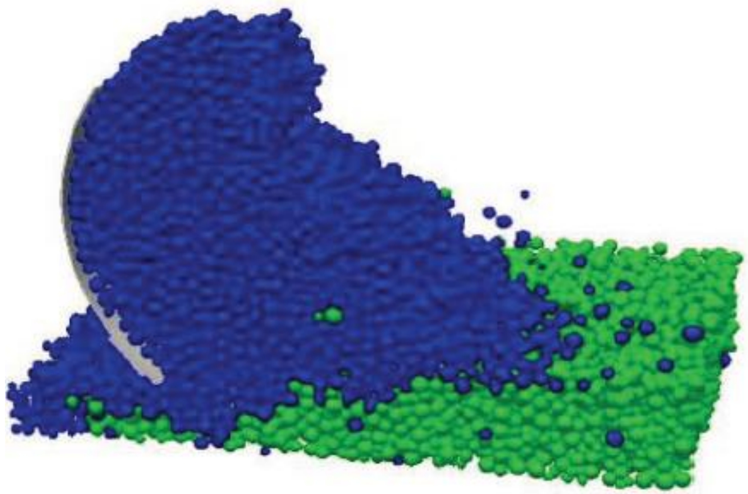
Energy efficiency for crawler dozers

Simulation of ground/ machine interaction





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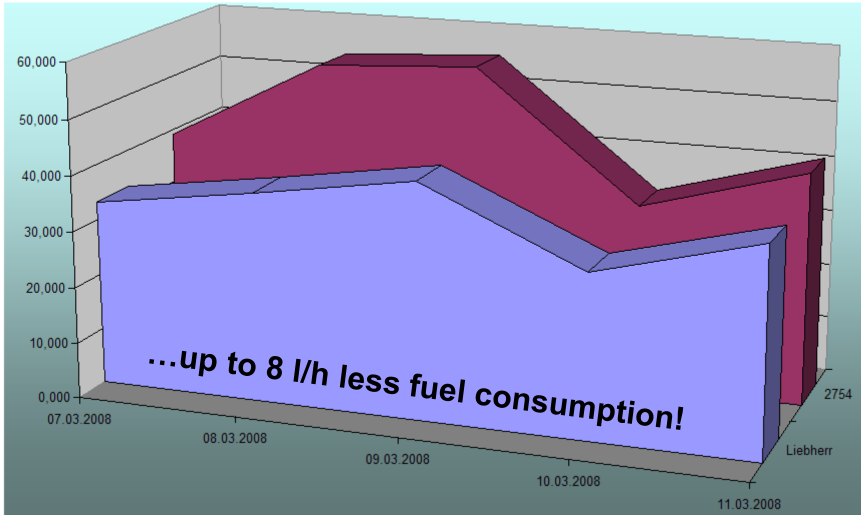
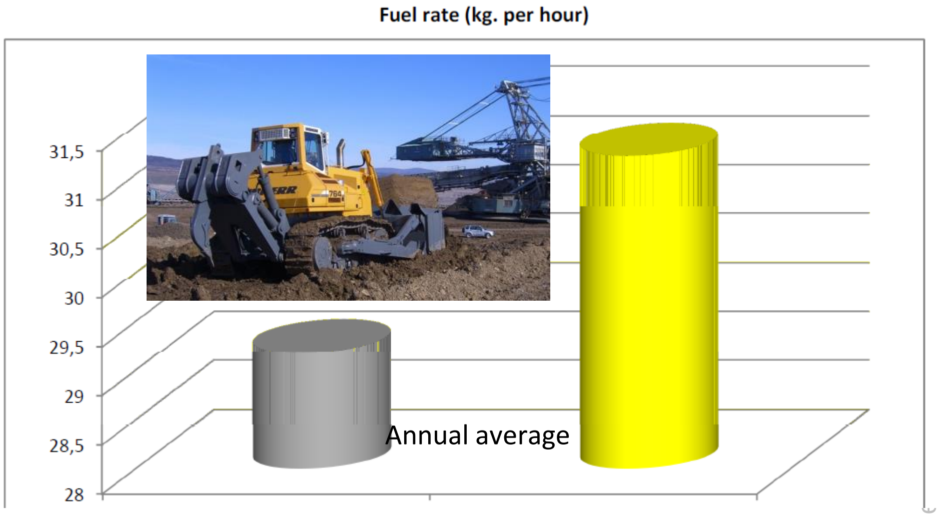
Energy efficiency for crawler dozers

Application	Operating weight up to 50t, electronically controlled hydrostatic travel drive

- Continuously adjustable hydrostatic travel drive
- Automatically controlled via TCU (Travel control unit)
- High efficiency over the hole speed range, based on optimal drive adjustments





Up to 15% less fuel consumption per hour

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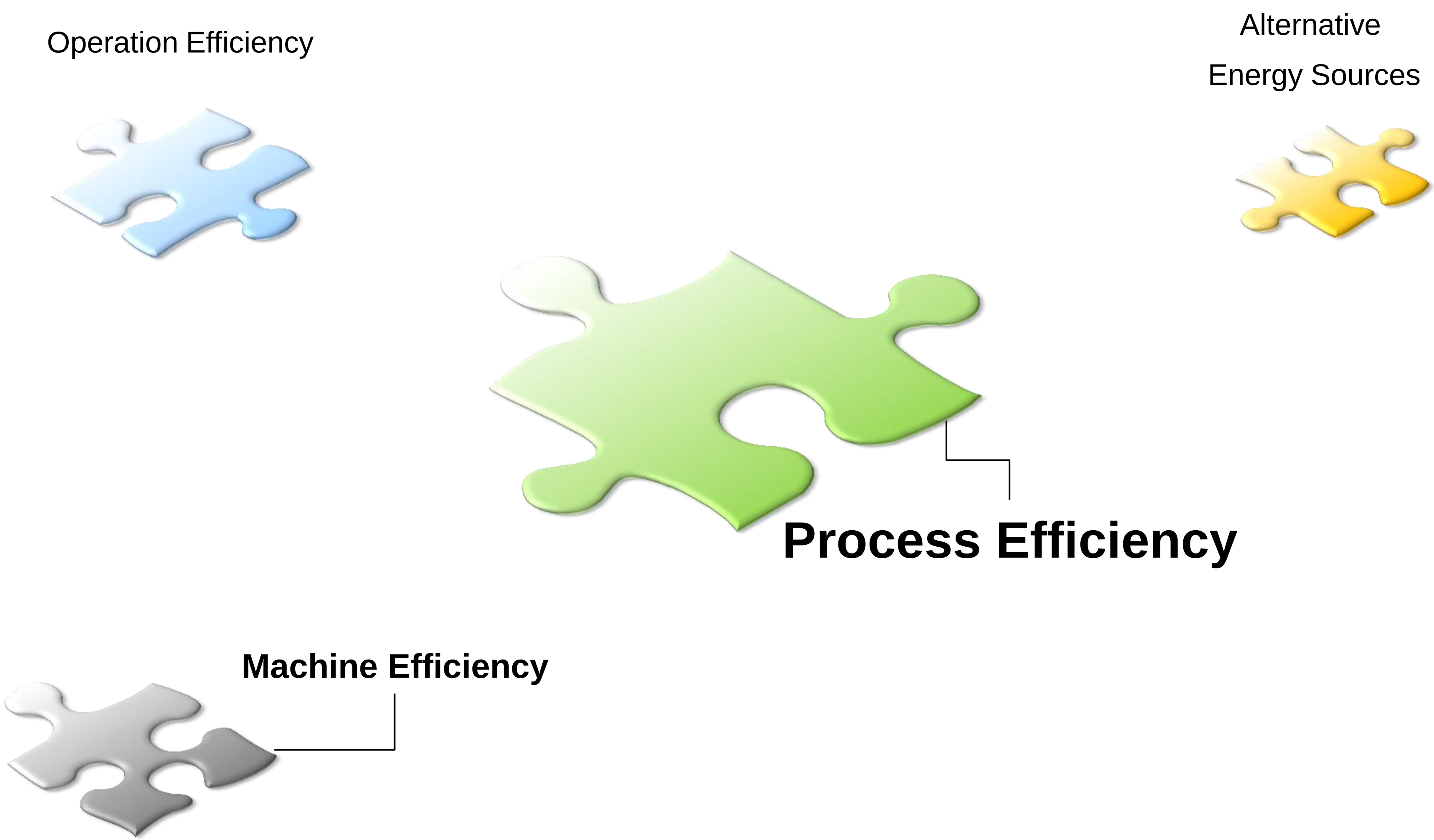
CO_2 - reduction: Process efficiency



CO_2 - reduction: Process efficiency

Process Efficiency

Results

- Automatic setting of hydraulic parameters after each tool change
- increasing of machine operating time of **about 40 %**
- Reduction of fuel consumption **up to 5 %**

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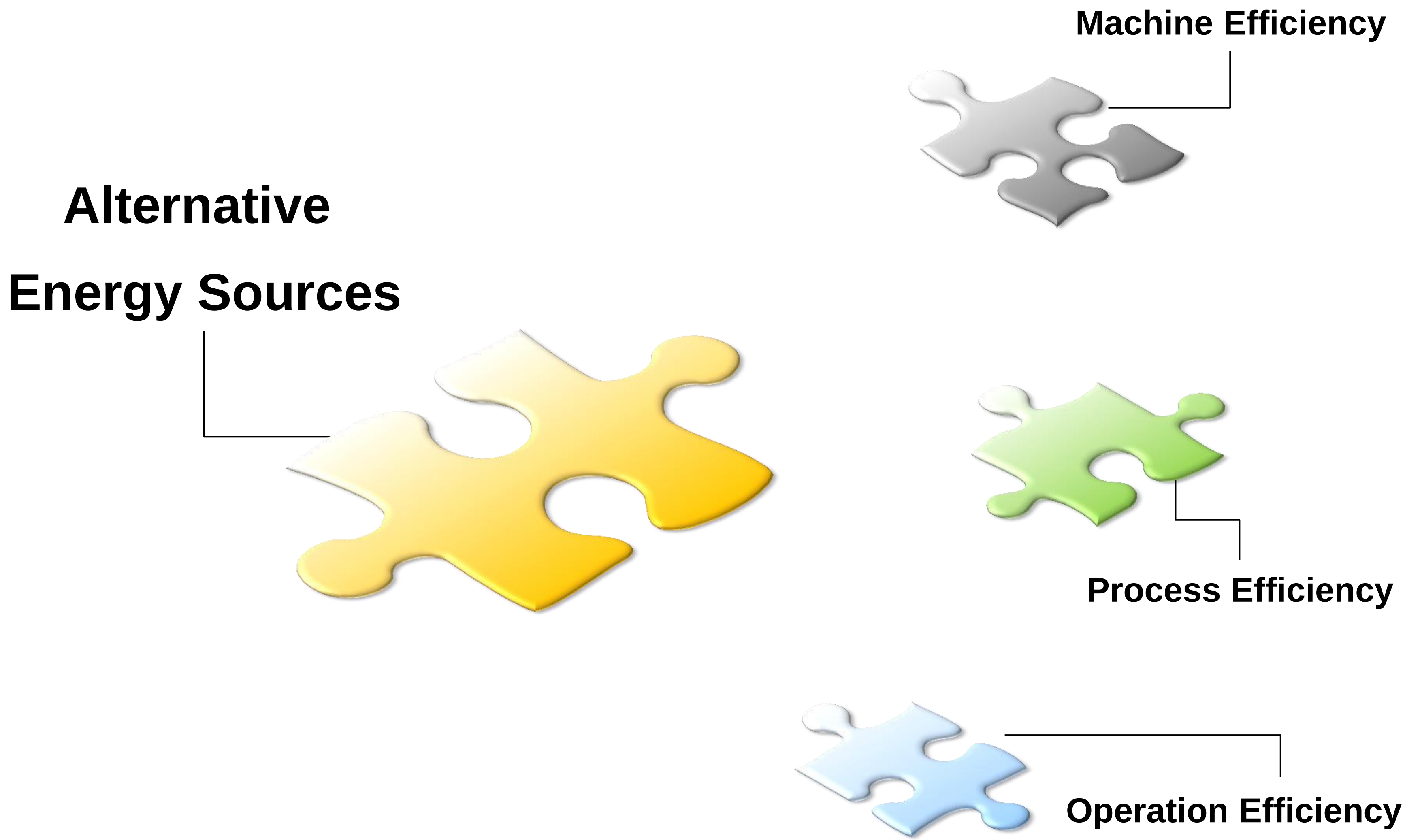
CO_2 - reduction: Alternative Energy Sources



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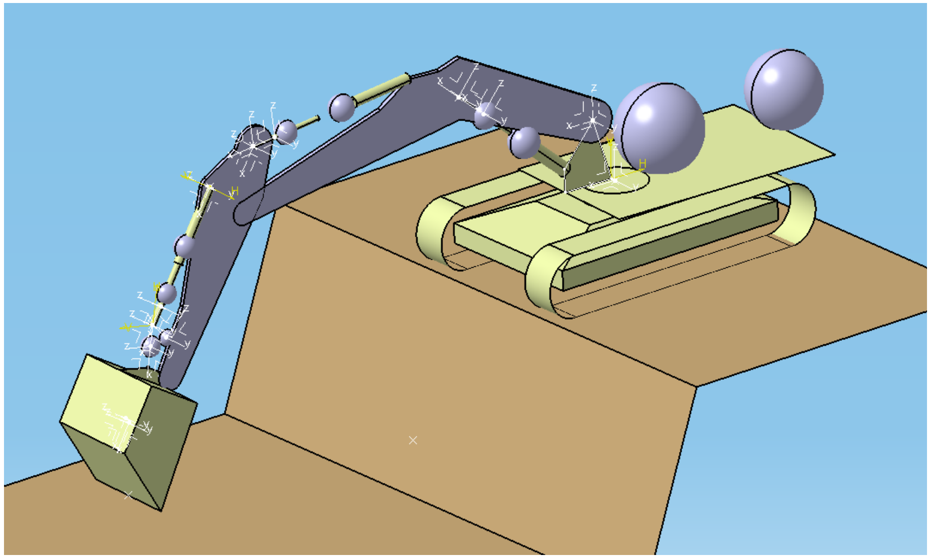
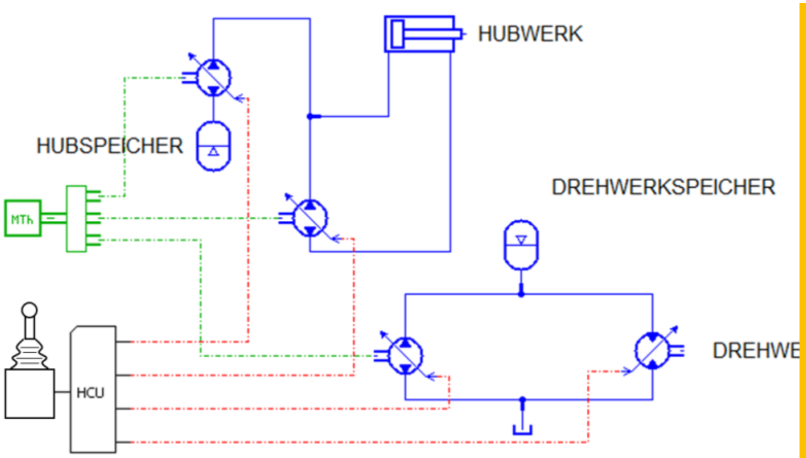
R 9XX concept
Highest fuel efficiency on all job sites
Maximum energy recovery for more performances
Fully integrated Liebherr system
Electrical panel
Downsized engine
Supercaps
Hydraulic accumulators
Reversible working pumps
Electric slew drive
New hydraulic system
Motor / Generator
9XX concept
LIEBHERR
Hydraulic
Electric
Energy Management
Fully integrated system
LIEBHERR

System simulation

Multibody simulation





Drive train modelling

- Component characteristics
- Simplyfied system (hyd. pumps, hyd.motors, Diesel-Engine,…)

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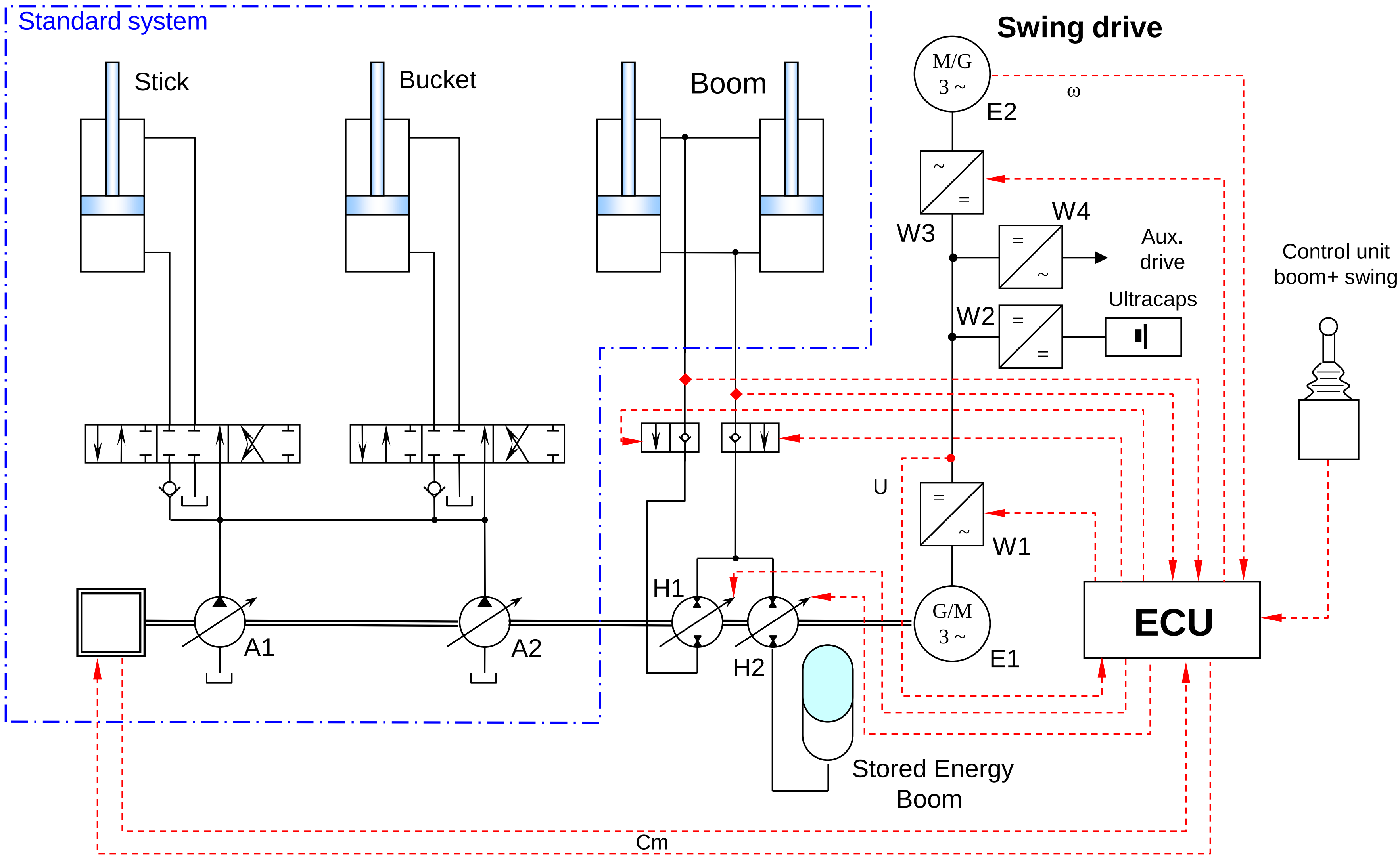
CO_2 - reduction: hybrid „drive system“ HEX



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Conclusions

- Mobile machines are designed for processes
- Wide range of diversified applications
- „4 pillars“ - approach is most effective
- Increasing „efficiency“ is increasing „customer added value“
- Industry is activly contributing to CO_2 reduction

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Conclusions

- Active joint research work is done to quantify CO_2 reduction for mobile machinery and their applications

- Research work will develop a tool to quantify CO_2 reduction based on the „4 pillars“ - approach

- Industry is asking for a strong support by official bodies to conduct these activities

One step ahead of tomorrow!

LIEBHERR

The scope of efficiency improvement in the agricultural machinery industry

Dr. Eberhard Nacke – 11.3.2015

|

Worlds productive agricultural area is clearly limited

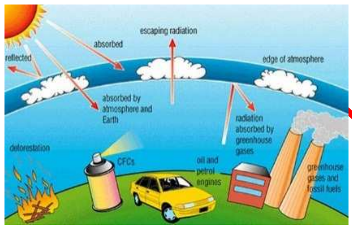
Still, there are more challenges to come

Water Shortage

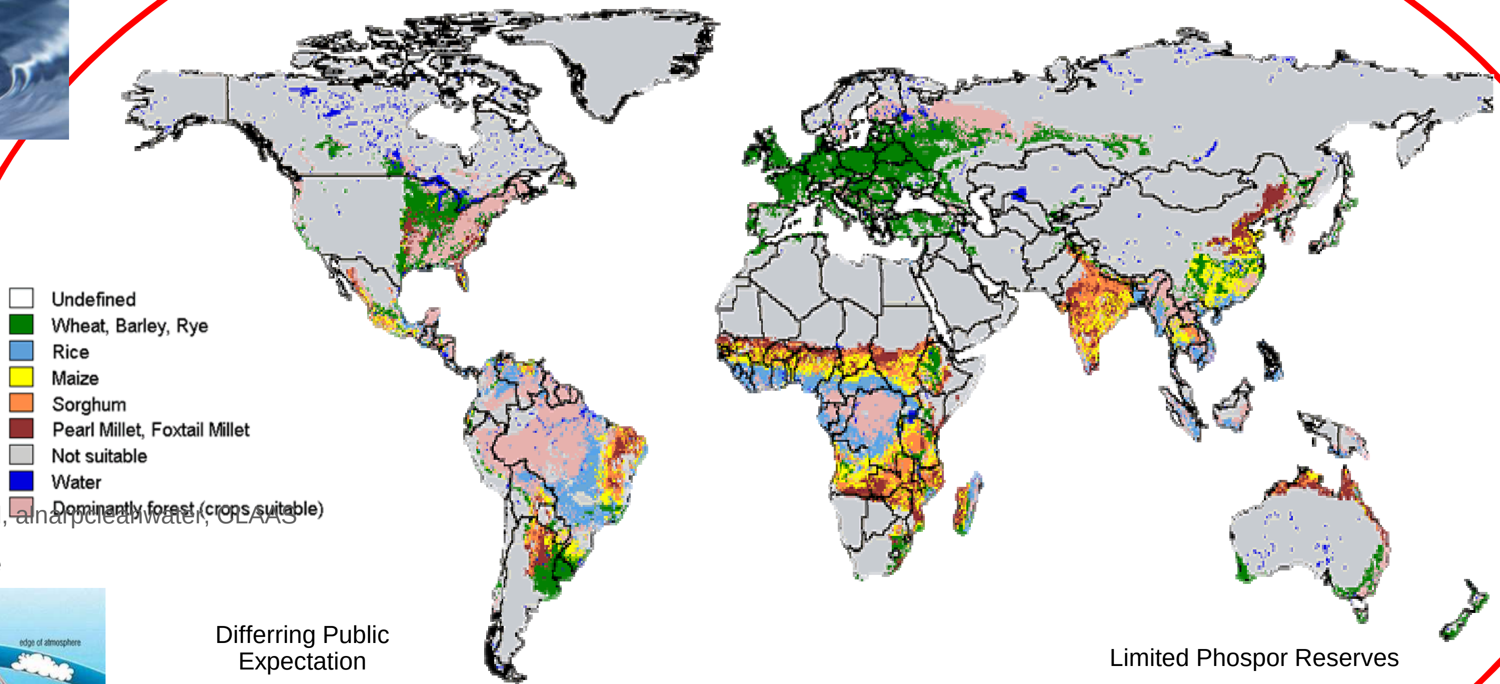
Weather Extremes

Photo source: FAO, Shell, alnarpcleanwater, CLAAS

Climatic Change



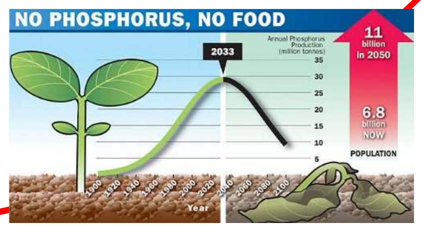
Good suitability for cereal cultivation
(without irrigation)



Differing Public Expectation

Limited Labour Availability

Limited Phospor Reserves



Population Growth

Changing Nutrition Habits

Limited Fossil Energy

Fundamentals of Agriculture in the decades to come

Management of Shortages
is the main driver of Future Farming Progress

- **Productivity**
- **Efficiency**
- **Precision**
- **Quality**

- **Management**

Sustainable

Intensification

of Agriculture

Efficiency not as an isolated goal, but as vital part of future farming philosophy

Productivity

Utilize limited resources at its best.

Efficiency

Efficiency criteria are critical factors in purchase decisions and vital for our global future.

Precision

Precision Agriculture shapes the future of agricultural engineering.

Quality and acceptance of society

Grow high quality food and explain how and why to the society

Management

Farming is not only art but business. Professional management is key for success

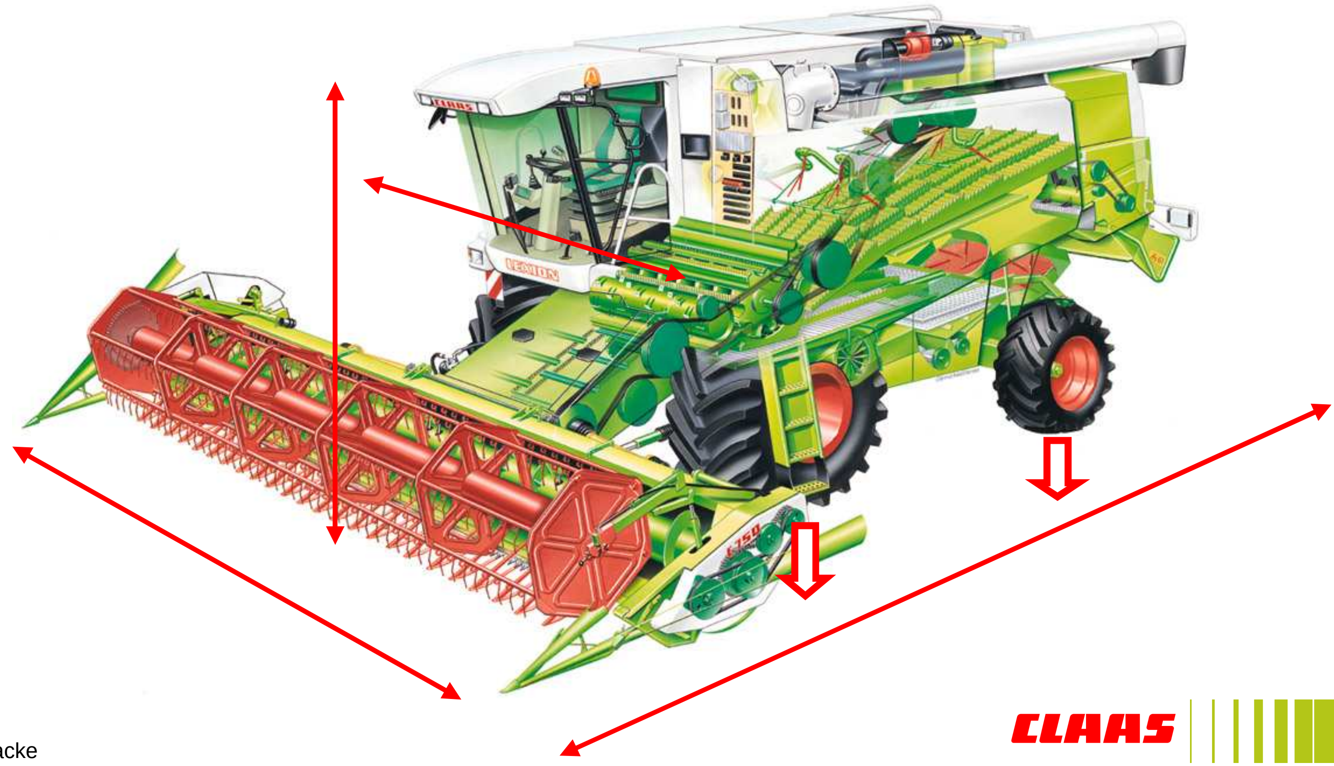
Sustainability

Think about the world of our great grand children developing today´s technology

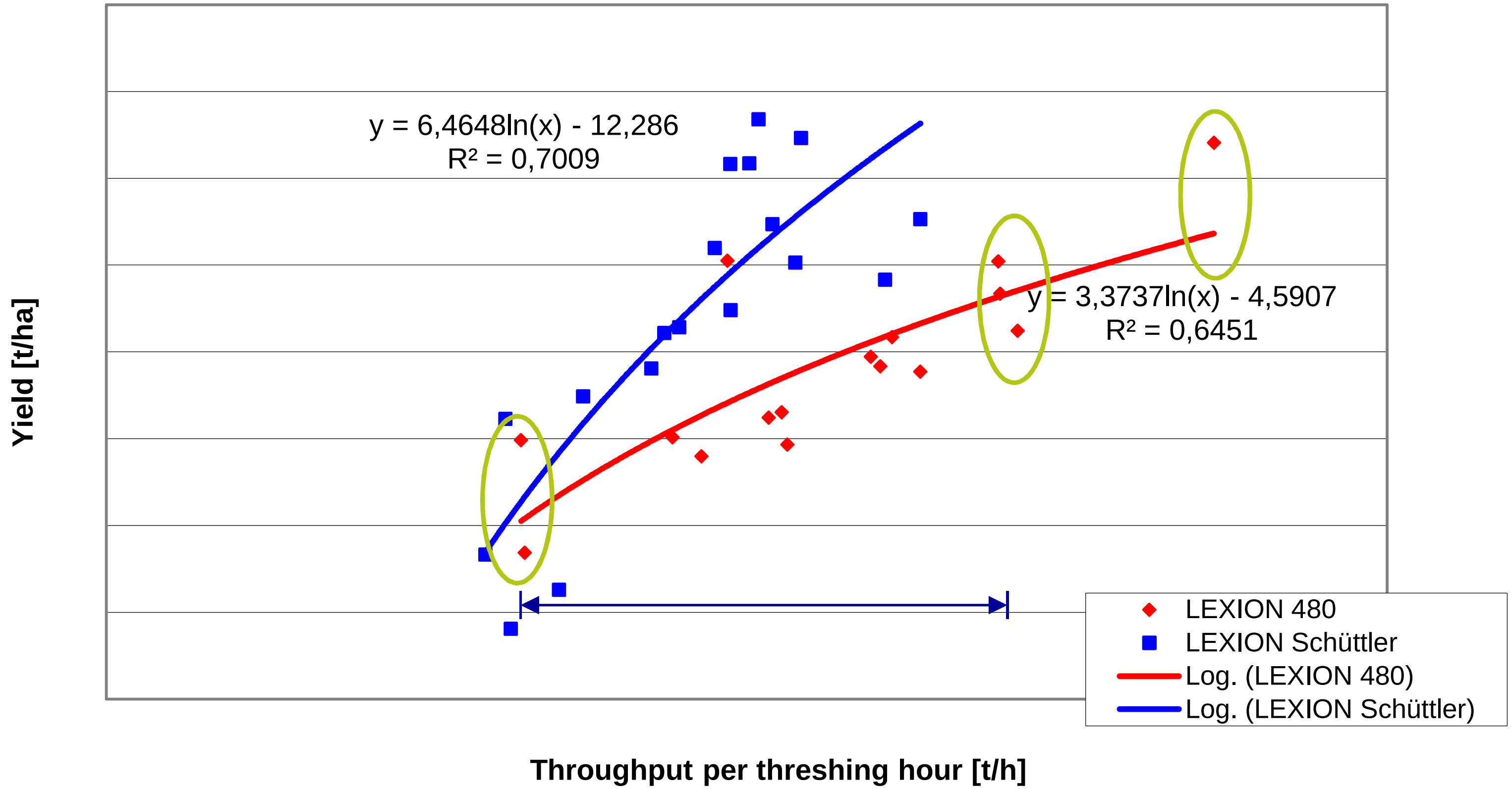
100 years of CLAAS - Labor productivity as main driver for growth

Size matters…

…but we are about to reach our limits

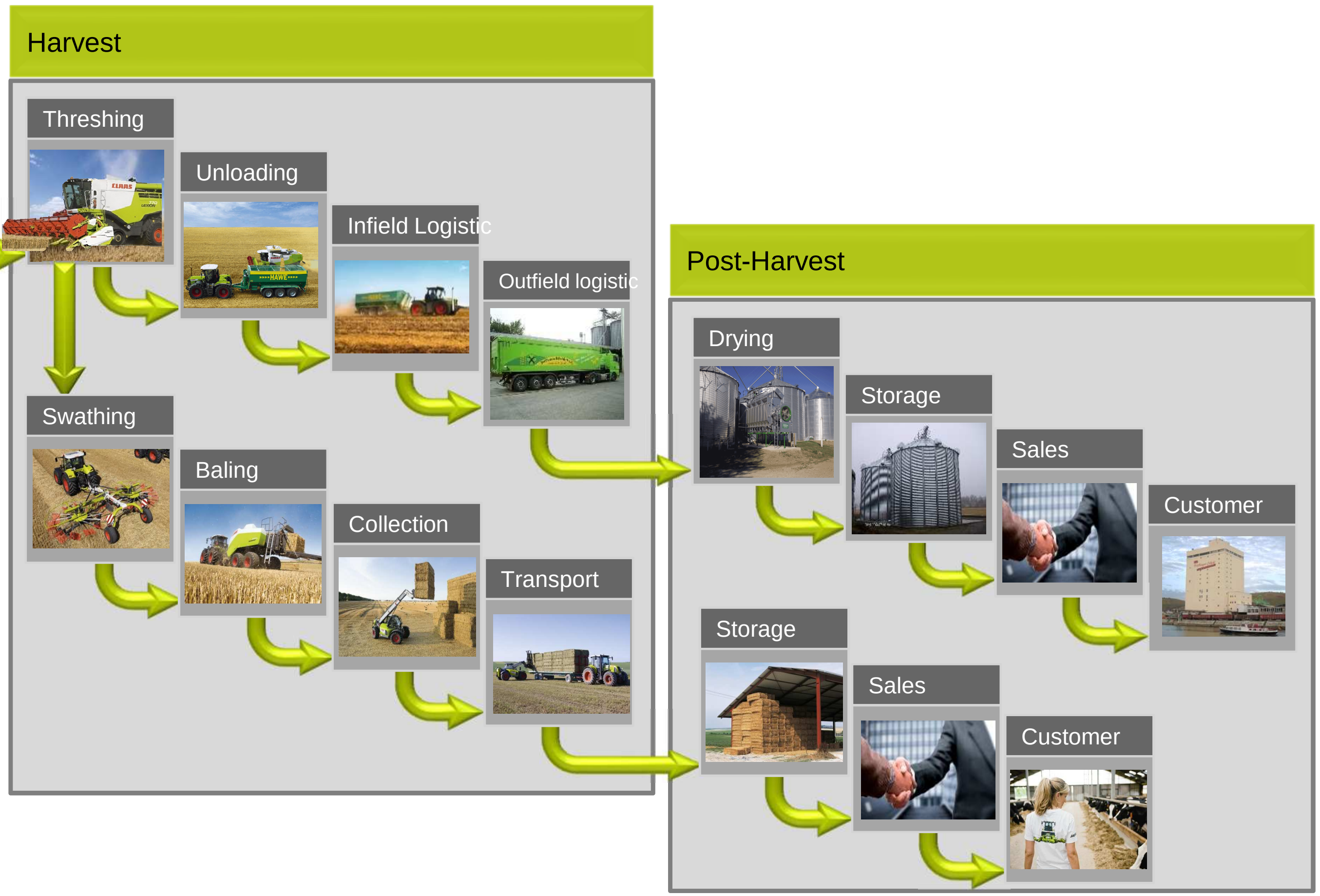


Realized average performance of identical combine harvesters



Tunnel Vision…

…Think in entire processes and not just in individual machines



Productivity - Optimize processes not just machines

Productivity and Efficiency…

…there is more than one denominator

- Labor efficiency has been the primary driver for progress in agricultural mechanization
- But there are more production factors at limit today

Limited Labor Availability

Limited Fossil Energy Reserves

Excessive Greenhouse Gas Emissions

Increasing Occurrence of Weather Extremes

Shortage of available Farmland

Shrinking Water Resources

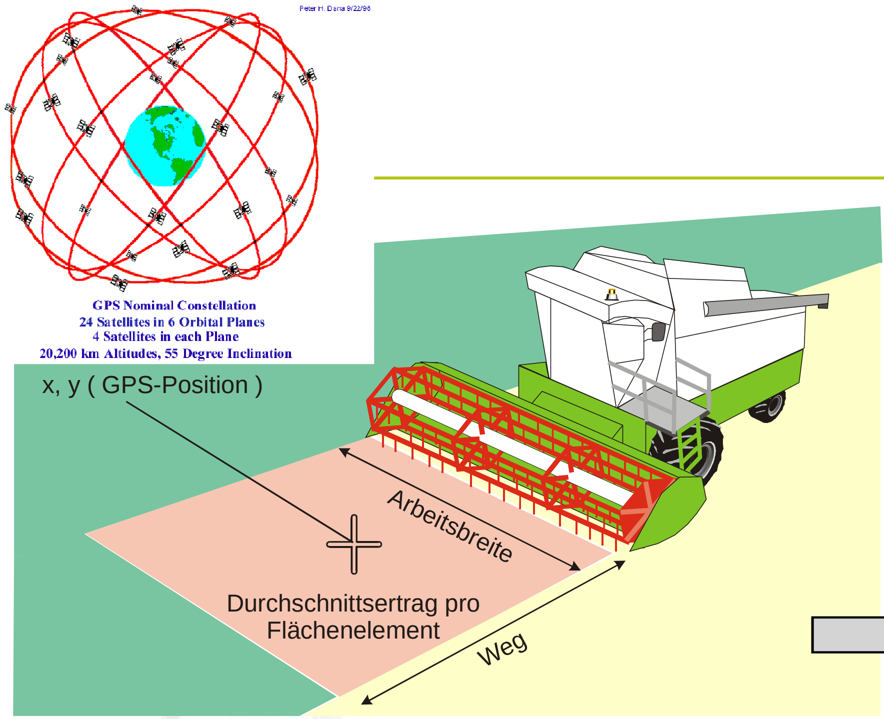
Limited Phosphate Reserves

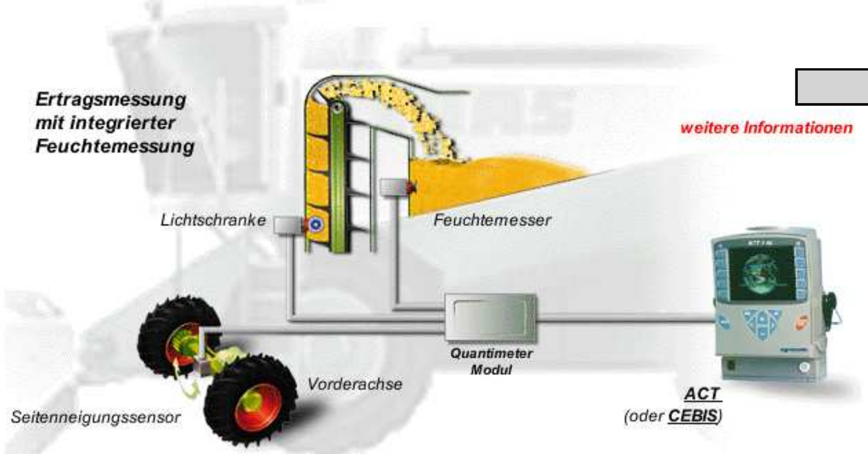
Limited Pesticide Effectivity

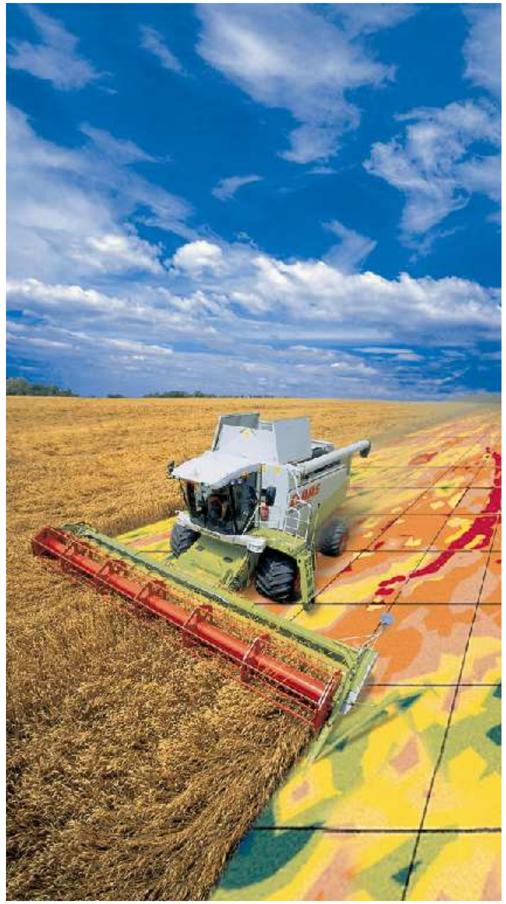
Productivity and Efficiency…

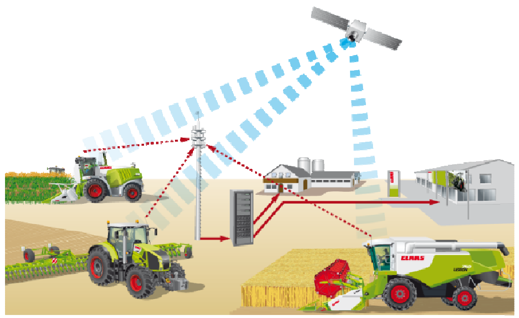
…there is more than one denominator

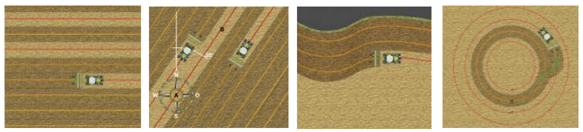
From GPS to a Yield Map

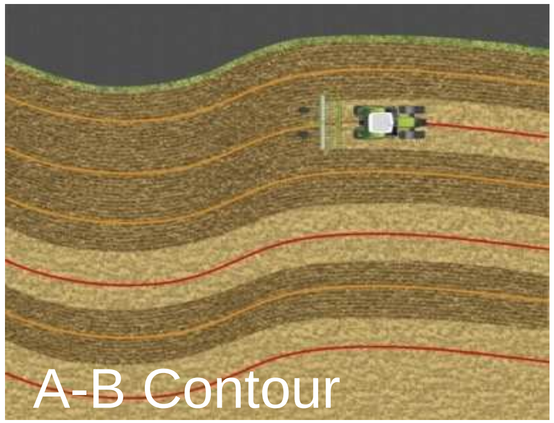






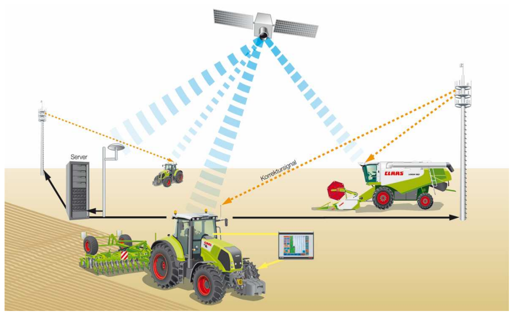




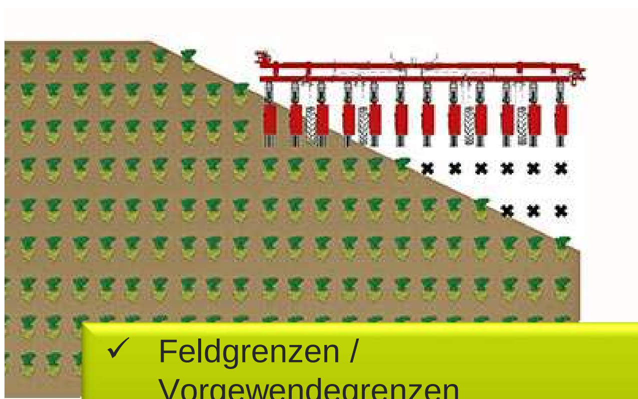

A-B Contour

Prozesseffizienz: Precision Agriculture

Strip Tillage



- ✓ High Precision GPS-Lenkung
- ✓ Übertragung von Referenzlinien zwischen Maschinen



- ✓ Feldgrenzen / Vorgewendegrenzen
- ✓ Section Control
- ✓ Potential für neue Strategien

Exakte automatische Lenkung als Basis

Strip Tillage
=
Weniger Bodenbearbeitung
=
Geringere CO_2 Emissionen

Established farming processes may be forced to change

K-State home » K-State Research and Extension News

K-State Research and Extension News

June 27, 2014

Share Email the story

Herbicide-Resistant Weed Threatens No-Till Farming

Photos available

Farmers increasingly resort to tillage to control Kochia

Herbicide-resistant black-grass: managing risk with fewer options

Ploughing (69% control)

Ploughing reduces the risk from grass weeds by burying freshly shed seeds to a depth from which seedlings are unlikely to emerge (>5 cm).

Black-grass seeds are relatively non-persistent in the seed bank (70–80% decline per year) so usually fewer old, buried seeds are brought back up to the surface, especially if ploughing is done on a rotational basis, once every 3–6 years.

Shallow non-inversion tillage the surface soil layer from where plants can readily emerge.

It does, however, avoid bringing large numbers of buried weed seeds back to the soil surface, so is preferable where little seed has been shed in the crop just harvested.

Failure to control black-grass effectively in shallow non-inversion tillage systems can result in a much more rapid increase in infestation (more than tenfold per year) than occurs in systems based on annual

Plan cultivation strategy at an individual field level to maximise control of black-grass.

Non-chemical methods – what level of control ca

The average levels of control given below are based on a comprehensive P J W Lutman, S R Moss, S Cook and S J Welham (2013), Weed Researc

Rotations

The prevalence of autumn-sown cropping is the main reason why black-grass is an increasing problem in the UK.

More balanced rotations are needed on many farms, not just to help in the control of grass weeds, but also to reduce the impact of pests and diseases and to impro soil fertility.

The inclusion of spring-sown crops is likely to be the most beneficial single element.

Re-evaluate crop rotations for long-term sustainability.

- **Legal restrictions of pesticides like glyphosate**
- **Pesticide resistances, e.g. black grass**
  - ✓ **Need for more tillage and more crop rotation**
  - ✓ **Negative effect on CO2 efficiency and productivity**

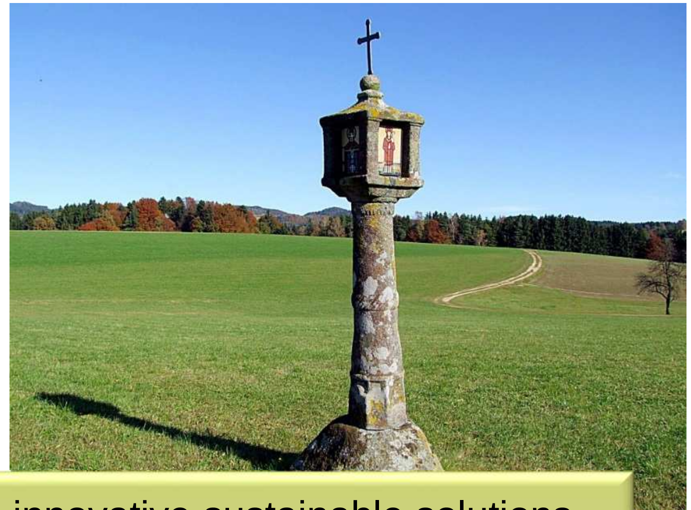
CLAAS

Public expectation differs often widely from farming reality

1. Quartal 2013
1.098.385
Verkaufte Auflage

LandLust

By far the most successful print media launched in 20 years



It is our duty not only to develop innovative sustainable solutions, but as well to explain modern agriculture to the public

Photo source: LV-Verlag, stefanolix, auweiler

Sustainability

How far would we like to grant to our great-grand children
that they may live as good as we are living today

Bildnachweis: Mr. Nico / photocase.com

Conclusion

We need BALANCE to reach the water

- High Tec solutions may provide tremendious opportunities to cope with global challenges
- But we need to concentrate on solutions, which are not just economically attractive, but which are do effectively cope with the challenge of limited global resources

- Sustainability is a question of balance between today´s needs and the needs of our great-grandchildren to be able to live as good as we do

KRONE

„Digital Farming“

Efficiency potencials of ICT in agriculture

11th of March 2015

KRONE

Agenda

Basics of Data Management in Agriculture

Machine Equipment supporting Agriculture

„ICT“ goes Farming

Cloud-based Knowledge Management

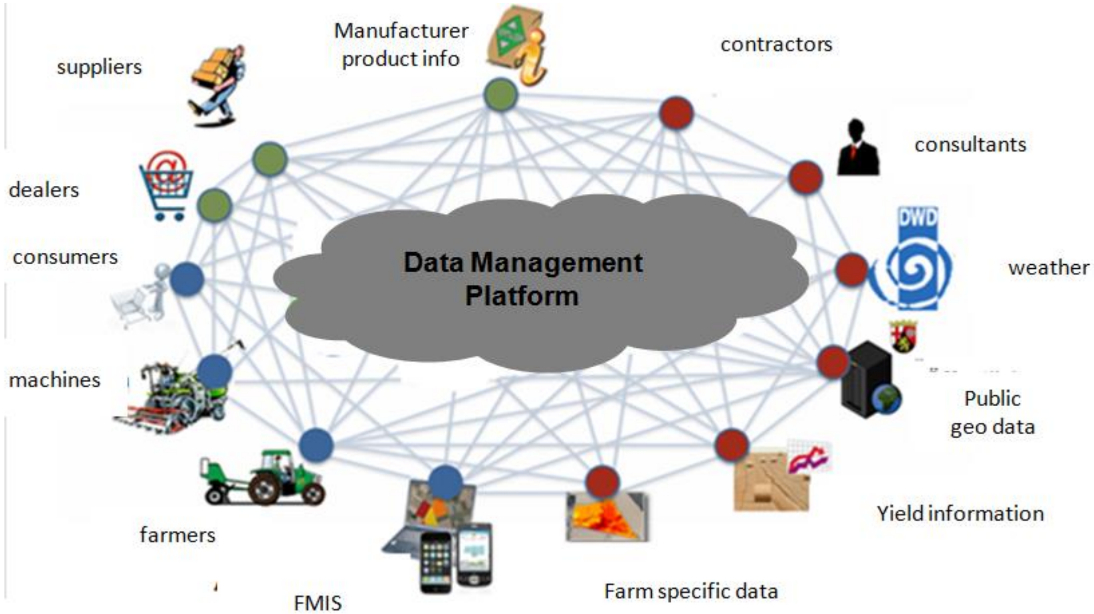
Summary and outlook

Multibrand- manufacturer independent data management

- time, task, machine, status, etc.
- location based data (position, sensor data, analyses, etc.)
- connectivity between involved parties (farmers, contractors, agronomists, etc.)

Data processing to gather information

Generation of knowledge and decision support



Location based services and decision support:

– Which task to execute next?
– Where to operate?
– Which means of production to use?
– When to operate the task? Which settings for the task?
– Local specialities?
– and further more…

Reasons to use ICT in agriculture

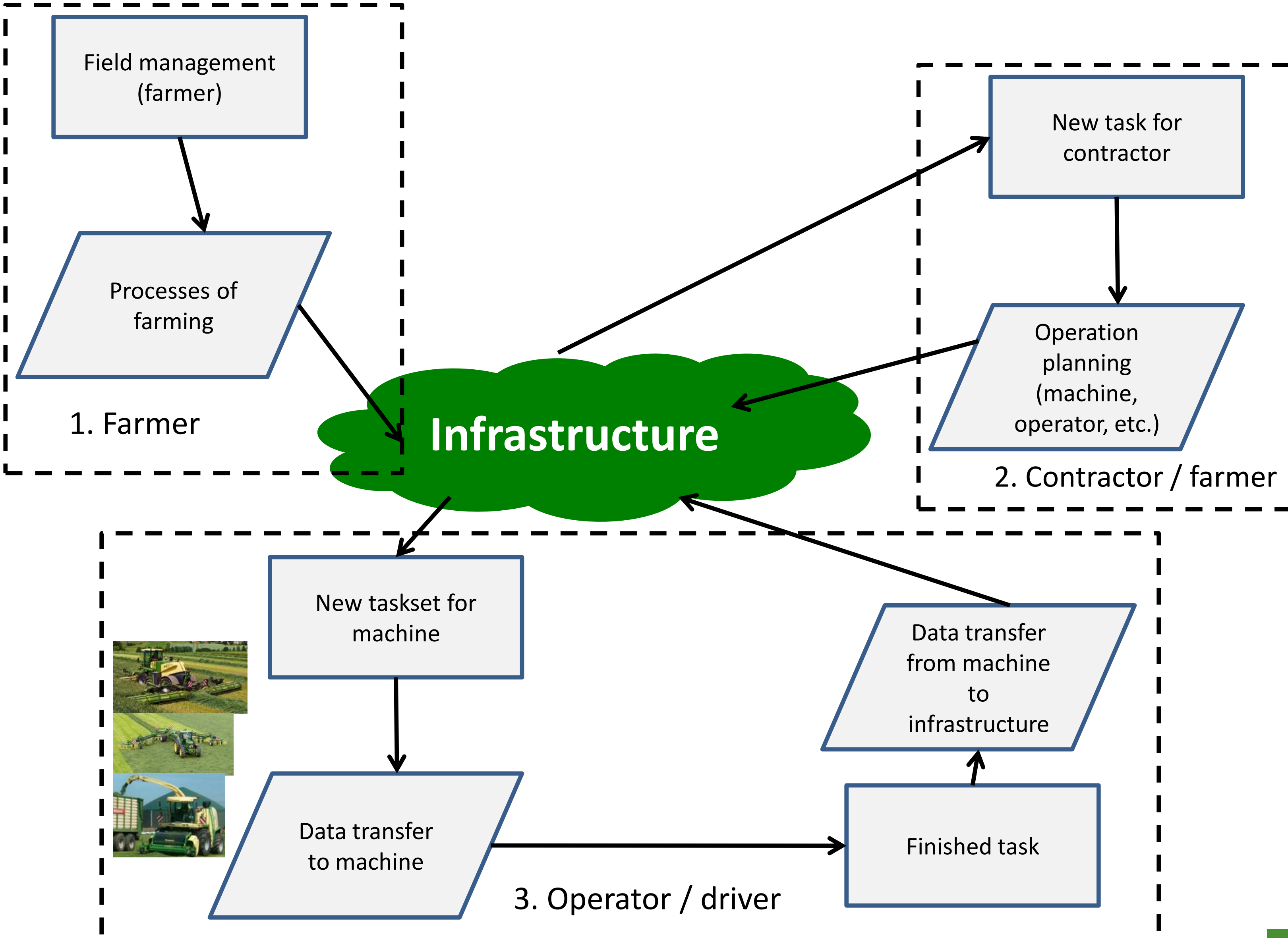
– many involved parties
– complex definition of operation places (partfield, size, specialities)
– agriculture has many manual processes with lot‘s of mistake potentials
– requirements of cross compliance and documentation are rising
– process optimization by ICT
– reduction of GHG

Basic ICT-Features can help to optimize processes:

- Machine Data Management
- Task Management
- Field Navigation
- Fleet Management
- Online Data-Transfer

- Billing & Controlling
- Weather & Forecasts
- Time Management
- Message Services
- Open Interfaces

Master plan for communication



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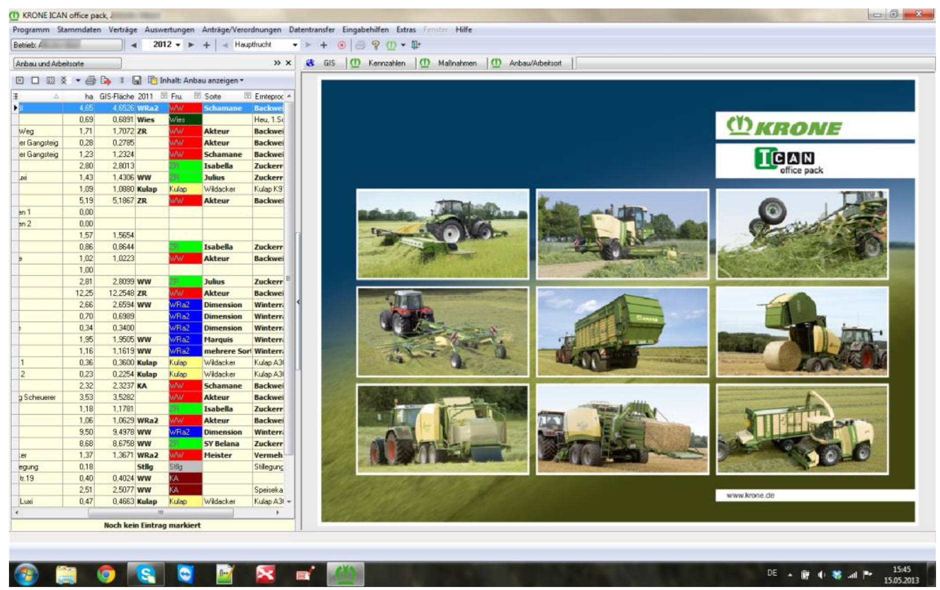
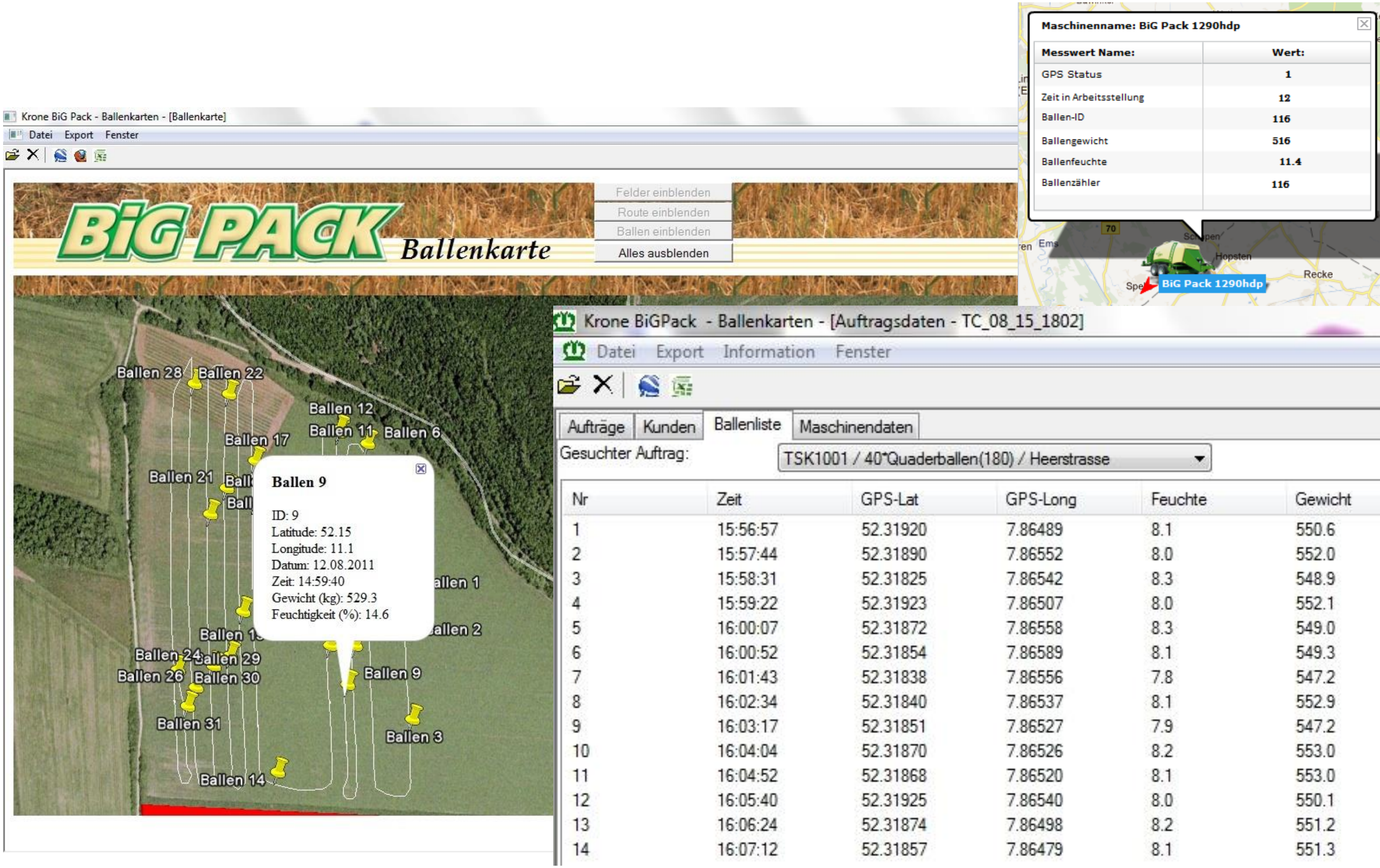
Some examples:





Nr	Zeit	GPS-Lat	GPS-Long	Feuchte	Gewicht
1	15:56:57	52.31920	7.86489	8.1	550.6
2	15:57:44	52.31890	7.86552	8.0	552.0
3	15:58:31	52.31825	7.86542	8.3	548.9
4	15:59:22	52.31923	7.86507	8.0	552.1
5	16:00:07	52.31872	7.86558	8.3	549.0
6	16:00:52	52.31854	7.86589	8.1	549.3
7	16:01:43	52.31838	7.86556	7.8	547.2
8	16:02:34	52.31840	7.86537	8.1	552.9
9	16:03:17	52.31851	7.86527	7.9	547.2
10	16:04:04	52.31870	7.86526	8.2	553.0
11	16:04:52	52.31868	7.86520	8.1	553.0
12	16:05:40	52.31925	7.86540	8.0	550.1
13	16:06:24	52.31874	7.86498	8.2	551.2
14	16:07:12	52.31857	7.86479	8.1	551.3

Sensors mounted on machines help to optimize processes in real-time

Example:
Optimum setting of chopping length and corn cracker distance helps to reduce energy consumption of a forage harvester
→ Saves fuel and therefore reduces emissions

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Summary and outlook

Communication and networking

Weather and geospacial infos

Maps and measurements

Personal services

Navigation and logistics

Fleet management

Service and support

Assistance for machine usage

...

...

Agricultural Apps

<u>Category A:</u>

- supports agriculture
- Dedicated use cases
- Assistence systems

Examples:
- spreading tables
- Weather
- machine optimization

Data management

<u>Category B:</u>

- supports processes
- Data management
- Fleet management
- Navigation

Examples:
- Precision Farming
- manure and logistics
- Fleet management
- ISOBUS Taskcontroller

Machine operation

<u>Category C:</u>

- operates a machine
- Provides service
- Replaces machine terminal

Examples:
- operation of loader wagon
- operation of seed driller
- operation of spreader

Quellen: Rauch
Väderstad
CCI

Agricultural Apps

Data management

machine operation

Quellen:
Rauch,
Landdata,
Kotte,
Claas,
BogBalle
Väderstad
CCI, Krone

iPad App: CCI Control Mobile

Optimization of processes

- ensure operation of correct field and area
- optimization of journey to the field entrance point
- machine operation with optimum settings and configuration
- determination of needed logistics
- weak point analyses

→ direct reduction of fuel

Indirect reduction of GHG

- precision farming reduces usage of fertilizer
- prescription farming contributes to optimize yields
- machines wear is reduced
- service and support processes are optimized

→ indirect reduction of energy consumption

Side effects

- controlling of operations and processes
- gathering data for future analyses and optimizations

→ Providing means for future improvements

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Summary and outlook

Cloud based knowledge management by services

Data hub

Public Services
- aerial photos
-Map material
-News
-Etc…

Location services
- Soil samples
- Material samples
- yield samples
-Etc…

consulting
- weather
- Soil maps
- Cultivation consulting
- Fertiliser consulting
- yield consulting
-Pest control and consulting
- Etc…

Social Media
- Supply chain
- Contractors
- farmers
- yellow pages of agriculture
- Message-Service
- advertising
- Etc…

CS Services
-RTK-signals
-Maschine connectivity
-Remote Service
-Etc…

Task management
-Geo-Information System
-Task planning
-Field management
- Etc…

Basic
- User administration
- billing
- Registration
- data security policy
- Etc…

Machine optimization
-Bedding tables
- Remote optimization
- setting consulting
- Etc…

Precision-Farming
-Section Control
- Exchange of A-B lines
- Electronic drawbar
- Etc…

Telemetry
- Fleet management
- Telematics
- harvesting services
- Etc…

accounting
- billing for operations
- controlling
- fuel book - monitoring
- Etc…

- Digitalization of agriculture
- Optimization of machines in combinations and fleets
- Cross Compliance and documation legal obligations
- Think in „Services“
- Bundling of resources
- Tendencies regarding web-based solutions

→ Same input – more output!
→ Reduction of GHG by comparison of input / output (output is always yield in tons!)

FT FINANCIAL TIMES

October 2013 – **Monsanto buys Climate Corporation for $930m**

www.FT.com – Monsanto, the agricultural products company, is looking to take advantage of the data surrounding more extreme weather patterns with …

THE WALL STREET JOURNAL.

February 2014 – **Data-driven planting increases yield by 33%**

*… The world's biggest seed company, Monsanto, estimates that data-driven planting advice to farmers could increase world-wide crop production by about **$20 billion a year**, or about one-third the value of last year's U.S. corn crop.*

+60% Produktionssteigerung bis 2050
33% ungenutztes Food-Produktion-Potenzial
$20 Milliarden Markt Potenzial für datengetriebene Anbauempfehlungen

Quellen: Financial Time
Wall Street Journal
United Nations

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Summary and outlook

ICT is available on the fields – GPS, Internet of Things and data management contributes to minimize the emission of GHG

- Process optimization
- planning
- navigation
- operation and machine settings
- decision support

-**Efficiency and effectivity**
- less fuel
- less furtilizer
- less overheads
- less soil compaction
- safeing money
- safeing the environment

-**Driver assistance and cross compliance**
- georeferenced pictures and videos
- automated documenation
- automated billing and controlling

ICT provides a boost in reduction of GHG during agricultural processes

Apps support agricultural processes

Apps connecting old equipment with modern farming machines

Apps become mobile and off- and online solutions

Apps and terminals as data management interfaces for process optimization

Cheap, quick and easy to handle solutions

Optimization of processes

Higher efficiency: planning, navigation, operation, management

Comprehensive solutions overcome todays borderlines

Future developments:

- web-based comprehensive agricultural data hub (manufacturer independent)

- Intelligent services
  - driver assistance
  - automated documentation and cross compliance
  - decision support and consulting

- self-optimizing process chains
  - dynamic process adaption
  - intelligent fleet management

- (particial-) autonomous and connected machines (IOT – internet of things)

Source: Krone

Source: Fendt

Source: Kongskilde

Source: Bayer Crop Science

Source: Amazone

ICT provides major improvements to reduce the production of GHG!

Maschinenfabrik Bernard Krone GmbH

Dipl.-Wirt.-Inf.(FH) Jan Horstmann
Leiter Elektronik und Produktinformatik
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Karlsruhe Institute of Technology

CHAIR OF MOBILE MACHINES

Sustainable energy storages for mobile machines

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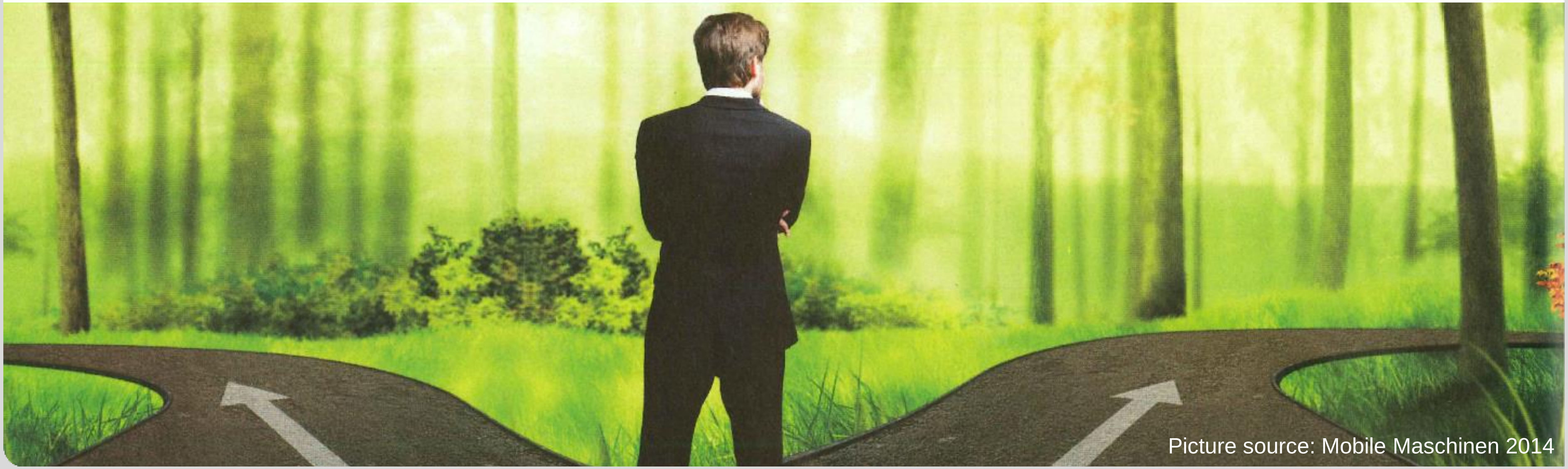
Director: Prof. Dr.-Ing. Marcus Geimer

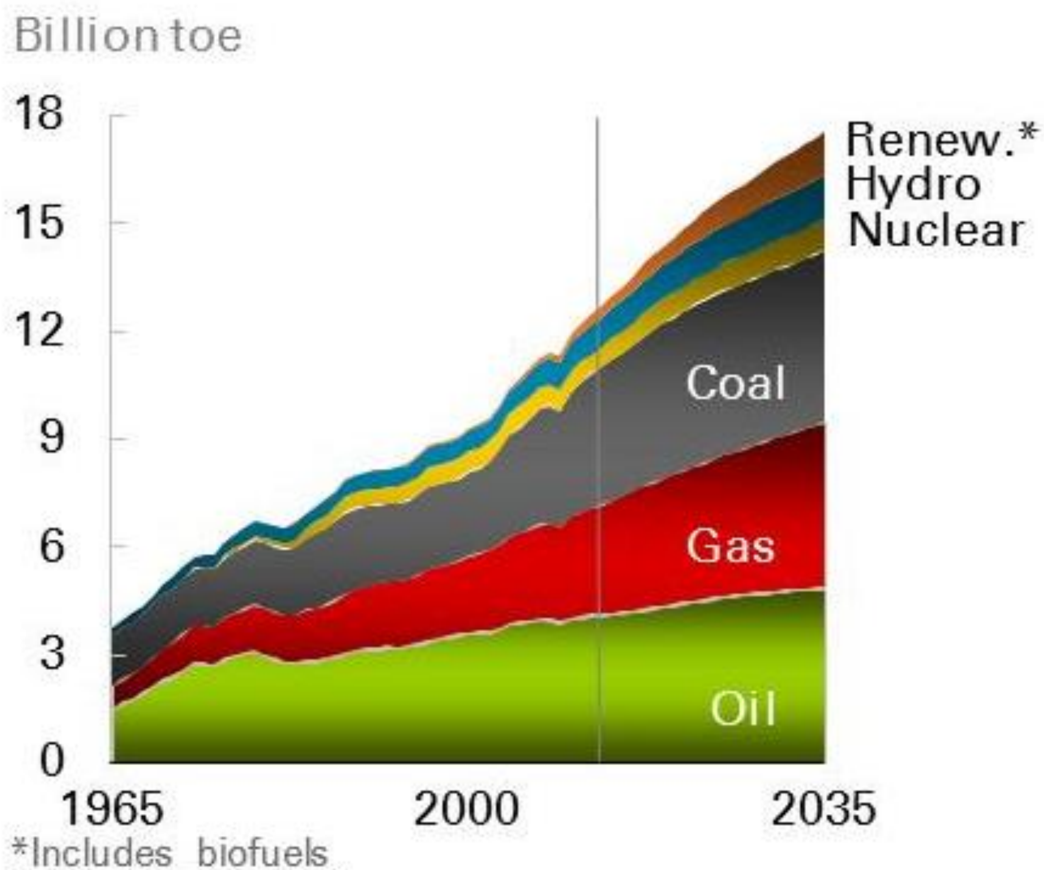


Picture source: Mobile Maschinen 2014

Agenda

1. Characteristics of energy storages and comparison basis
2. Gaseous energy storages
3. Liquid energy storages
4. Solid energy storages
5. Summary

Energy outlook of fuel consumption



Source: BP 2014

Definition: Sustainable

Picture source: Internet

Boundary conditions

- Discontinuous supply of energy
- Comparison basis: combine harvester with 500 l fuel tank
- Today known and confirmed technologies
- Prediction time:
  20 years

Picture source: [2]

Calculation basics

- Energy capacity:
  E [MJ] = tank volume [l] * spec. weight [kg/l] * energy density [MJ/kg]
- Efficiency of the combustion engine:

$$\eta = \frac{1}{b_e \cdot h_u} \approx 34\ \%$$

$$b_e = 250\ g/kWh$$

- Effective energy:

$$E_{Eff} = E * \eta$$

- Mass of the electric storage:

$$m_{Batt} = \frac{E_{Eff}}{\text{energy density} \cdot \text{electric efficiency } [\eta=0{,}8]}$$

Energy density

1 2 3 4 5

Elements	Energy density [MJ/kg]	Source
Electric double-layer capacitor	0,00036 to 0,036	[3]
Lead battery	0,09	[4]
Lithium-Ion battery	< 0,54	[4]
Lithium-Air battery	0,5-1,62	[5]
Ethanol	26	[6]
Dimethyl ether	30,8	[7]
Rape oil	37,2	[6]
Diesel	43,2	[6]
Petrol	44	[6]
Natural gas	45	[6]
Biogas	50	[8]
Hydrogen	120	[6]
Nuclear fission	79.000000	[9]

Agenda

Gaseous sustainable energy storages

1 2 3 4 5

- Hydrogen (H_2):

  electrolysis: $2\ H_20 + \text{energy} \rightarrow 2\ H_2 + O_2$

  (sustainable electric energy is needed, process today well known)

- Biogas
  microbial degradation of organic substance (anaerobic fermentation)
  i.e. biogas plant
  product:
  ~ 75 % methane & ~ 25 % CO_2

- Methane (CH_4)
  → see next page

Picture source: Internet

Methane

- Methanisation:

$$CO_2 + 4\,H_2 \rightarrow CH_4 + 2\,H_2O$$

- Efficiency of the process [10,11]
  - Electric power → hydrogen (H_2): 54 .. 80 %
  - Hydrogen (H_2) → methane (CH_4): 75 .. 95 %
  - Overall efficiency: electric power → methane: 50 .. 70 %

Picture source: Internet

Evaluation of the gaseous sustainable energy sources

- Reference: diesel fuel with: 500 l / 415 kg
- Hydrogen:
  - 200 bar storage: 8.788 l / 149 kg
    (energy density: 120 MJ / kg, density: 0,017 kg / l)
  - Metal hydride storage: … l / 3.311 kg
    (weight ratio: today known as 1,7 .. 4,5 %, calculation: 4,5 %)
  - Liquefied 2.074 l / 149 kg
    (energy density 120 MJ / kg, density: 0,071 kg / l)
- Methane / biogas
  - 200 bar storage: 2.656 l / 359 kg
    (energy density: 50 MJ / kg, density: 0,135 kg / l)
  - Liquefied: 854 l / 359 kg
    (energy density: 50 MJ / kg, density: 0,42 kg / l)

Picture source: Internet

Agenda

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3. **Liquid energy storages**
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Liquefied energy storages

- Bio-chemical conversion
  - Alcoholic fermentation:
    sugar, grain or cellulose is transferred to ethanol (C_2H_3OH)
    → today already well known in E10 petrol (10 % ethanol)
  - Anaerobic fermentation:
    → see biogas plant
  - Composting:
    high time constant, i.e. not taken into account here
- Physic-chemical conversion:
  - Squeezing of plants (in Europe: rape seeds) and additional ester interchange: oil/grease + methanol → biodiesel + glycerine
    (the use of 100 % biodiesel needs a modification of the combustion engine)

Picture source: http://www.bioliq.de

Liquefied energy storages

- Thermo-chemical conversion
  - i.e. pyrolysis, Fischer-Tropsch-synthesis, dimethyl ester-synthesis:

    pyrolysis: organic substances are cracked at high temperature
    result: pyrolysis oil and H_2, CO, CO_2 and methane (CH_4)
    → pyrolysis oil is under research today
    gaseous parts are used for Biomass-to-Liquid (BtL) fuels

    synthesis: composition of two or more parts into a product
    → production of liquefied fuels are of interest

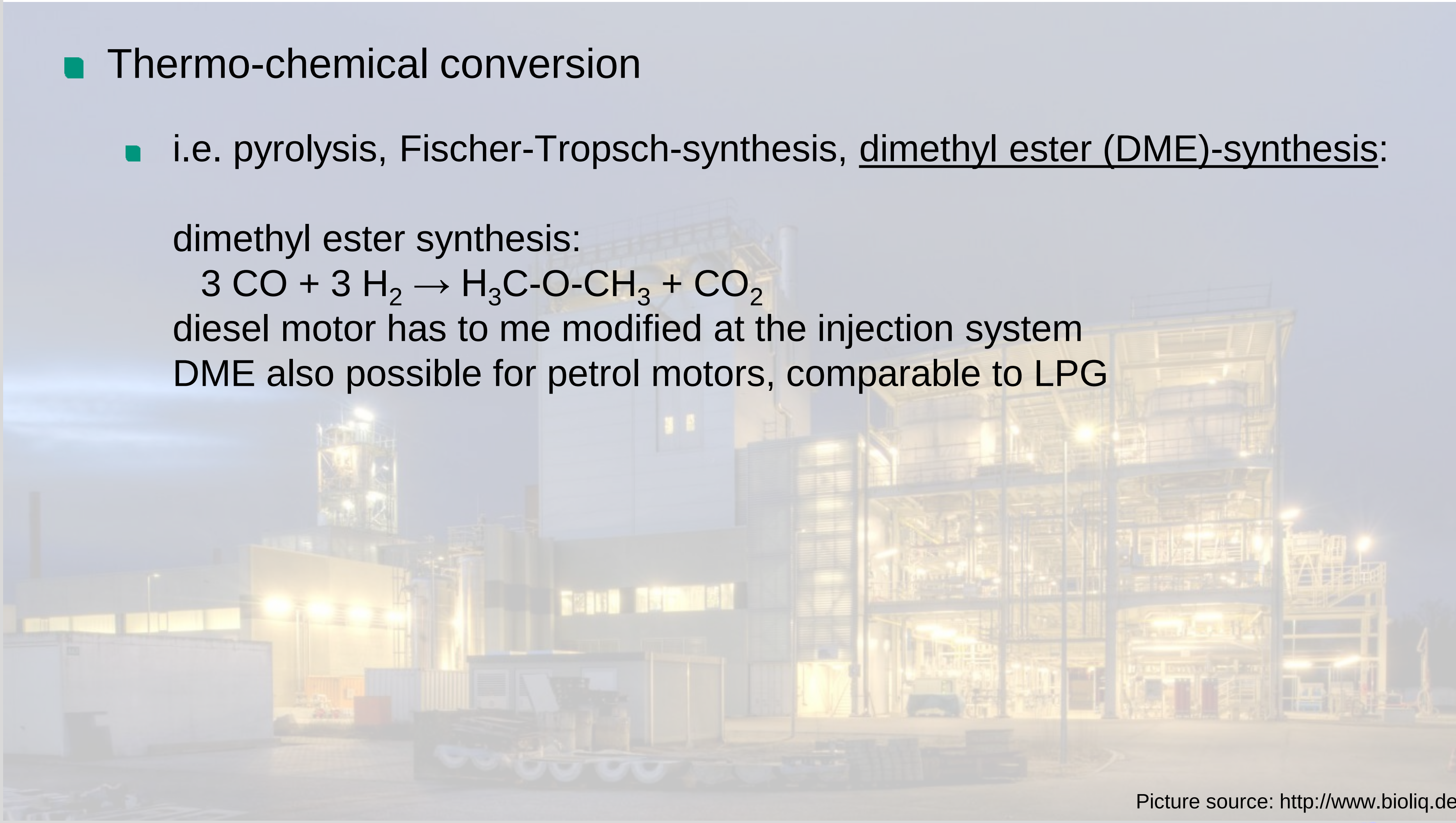
    Fischer-Tropsch-synthesis: developed to produce liquefied fuels from coal
    → production of fuel from methane is possible:
    $CH_4 + H_2O \rightarrow CO + 3\,H_2$; $2\,CH_4 + O_2 \rightarrow 2\,CO + 4\,H_2$
    → hydrocarbons: $2n\,H_2 + n\,CO \rightarrow n(-CH_2-) + n\,H_2O$

Picture source: http://www.bioliq.de

Liquefied energy storages

- Thermo-chemical conversion
  - i.e. pyrolysis, Fischer-Tropsch-synthesis, <u>dimethyl ester (DME)-synthesis</u>:

    dimethyl ester synthesis:
    $3\ CO + 3\ H_2 \rightarrow H_3C\text{-}O\text{-}CH_3 + CO_2$
    diesel motor has to me modified at the injection system
    DME also possible for petrol motors, comparable to LPG



Picture source: http://www.bioliq.de

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Solid energy storages

- Electric batteries
  - Very poor energy density (0,09 .. 1,62 MJ / kg)
  - Lithium-air battery:
    energy density: up to 1,62 MJ / kg expected → mass = 4.703 kg
    (today possible: 0,5 MJ / kg → mass = 15.239 kg
- Oxidation of aluminium:
  $$2\ Al + 2\ H_2O \rightarrow Al_2O_3 + 3\ H_2 + \text{energy}$$

  possible reaction: nano or liquid aluminium + liquid or heated water
  heat can not be used in mobile machines; H_2 use is possible:
  $$1\ kg\ Al + 1{,}0015\ kg\ H_2O \rightarrow 1{,}8995\ kg\ Al_2O_3 + 0{,}112\ kg\ H_2$$

→ 2.662 kg Al + H_2O used as energy equivalent

Picture source: http://www..kit.edu

Size of energy storages for 6.096 MJ

Energy storage	Calorific value [MJ/kg][1]	Volume [l]	Mass [kg]
Diesel	43,2	500	415
Petrol	44,0	543	407
Methane (15°C; 200 bar)	50,0	2.656	359
Methane (-167°C; 1 bar)	50,0	854	359
Hydrogen (200 bar)	120,0	8.788	149
Liquefied hydrogen	120	2.074	149
Biogas (15°C; 200 bar)	50,0	2.656	359
Ethanol	26,0	878	690
Dimethyl ether (DME) (at -25°C)	30,8	882	583
Raps methylester	37,2	548	482
Lithium-air battery	0,5-1,6	-	4.150 - 12.450
Aluminium oxidation		Al & Water: 1.823	Al & Water: 2.662

[1] sources: [6,7 and 8]

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Sustainable energy storages for mobile machines

- Methane:
  - 200 bar pressure: known technology, like CNG
  - Liquefied: LNG technology known in ships and trucks
    → technology has to be adapted
- Bio-fuels (ethanol, dimethyl ether, biodiesel):
  → combustion engine has to be modified, know technology
- Electrical storages
  → no potential for a wide range of use in mobile machines
  (niches like forklift trucks are widen)

Picture source: Mobile Maschinen 2014

references

[1] Geimer, M. und I. Ays: Nachhaltige Energiekonzepte für mobile Arbeitsmaschinen – in welche Richtung gehen sie?, Mobile Maschinen, 6/2014, S. 18-25.

[2] P. Thiebes und M. Geimer, „Energiespeicher für mobile Arbeitsmaschinen mit Hybridantrieben," in 1. VDI Fachkonferenz: "Getriebe in mobilen Arbeitsmaschinen", Friedrichshafen, 2011.

[3] S. Heier, C. Rose und Y. Bouyraaman, „Elektrische Energiespeicher," Seminar Netzintegration dezentraler Einspeisesysteme SS 09, Universität Kassel, Kassel, 2009.

[4] D. U. Sauer, „Optionen zur Speicherung elektrischer Energie in Energieversorgungssystemen mit regenerativer Stromerzeugung," Juniorproffessur für Elektrochemische Energiewandlung und Speichersystemtechnik,Institut für Stromrichtertechnik und Elektrische Antriebe (ISEA), RWTH Aachen, Aachen, 2006.

[5] F. Endres, „Grenzflächen in Lithium(Ionen)-Batterien," Bericht vom Bunsenkolloquium, Bunsen-Magazin, Nr. 4 - Juli 2011, ISSN 1611 - 9479, pp. 112-116, 24./25. 03. 2011.

[6] C. Stan, „Altenative Antriebe für Automobile Hybridsysteme, Brennstoffzellen, alternative Energieträger," 3., erweiterte Auflage, ISBN 978-3-642-25267, Springer-Verlag, 2012, p. 187 ff.

[7] T. A. Semelsberger, R. L. Borup und H. L. Greene, „Dimethyl ether (DME) as an alternative fuel," Elsevier, Journal of Power Sources 156, 2005.

[8] A. Velji, M. Lüft, K. Pabst und G. Schaub, „Neuartige Kaftstoffe und zukünftige Abgasemissionen bei Kraftfahrzeugen - eine Übersicht," Engler-Bunte-Institut & Institut für Kolbenmaschinen, Karlsruhe, 2007.

[9] A. F. Badea, Grundlagen der Energietechnik, Karlsruhe: Unterlagen zur Vorlesung am Karlsruher Institut für Technologie (KIT), 2012.

[10] M. Sterner, „Bioenergy and renewable power methane in integrated 100% renewable energy systems," Dissertation, ISBN 978-3-89958-798-2, Universität Kassel, Kassel, 2009.

[11] S. Stucki und P. Scherrer, „Produktion gasförmiger Kraftstoffe- Stand der Technik," Paul Scherer Institut (PSI), 23. 07. 2007. [Online]. Available: http://web.archive.org/web/20071009233729/http://www.ie-leipzig.de/Veranstaltungen/11_Stucki.pdf. [Zugriff am 27-28. 02. 2007].

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Leibniz-Institut für Agrartechnik
Potsdam-Bornim e.V.

What prevents us from using more efficient technology?

Prof. Dr. Reiner Brunsch,
Claire Nicolas (Ing. AgroParisTech)

Symposium “Efficiency of mobile machines and their applications – a contribution to the reduction of GHG”
March 11th, 2015 - Braunschweig

Leibniz-Gemeinschaft

Outline

- Diffusion and adoption process of innovations in agriculture
- The agricultural innovation system in Germany
- Energy efficiency in agriculture as an example
- Precision Agriculture as an example
- Conclusion and outlook

Preliminary remark:
The link between innovation and efficient technology

- Assumption: efficient technology results from an innovation process.
- Innovation(s):

"technological factor that changes the production function and regarding which there exists some uncertainty, whether perceived or objective (or both). The uncertainty diminishes over time through the acquisition of experience and information, and the production function itself may change as adopters become more efficient in the application of the technology." (Feder & Umali, 1993)

"the basic elements of technological and institutional change. Innovations are defined here as new methods, customs, or devices used to perform new tasks." (Sunding & Zilberman, 2001)

Diffusion and adoption process of innovations in agriculture
Complexity and determinants for adoption of innovations
(Possas et al., 1996; Feder & Umali, 1993)

- Sources of innovation in agriculture have diverse disciplinary as well as competitive strategic origins.
- Sources are not only industries but also public research and education institutions, producer organizations and private and public research foundations.

- innovation diffusion as a dynamic and complex process
- Major determinants of the speed of technology adoption by various users (empirical studies of the early phases of diffusion processes): farm size, tenure status, education, access to extension services, credit.
- However, those determinants have often faded into insignificance in the later stages of the diffusion cycle.

Diffusion and adoption process of innovations in agriculture
Policy Interventions and Technology Adoption
(Feder & Umali, 1993)

- speed and extent of technology application in commercial operations lead to improvements in productivity and product quality
- the faster a superior technology is diffused, the larger the improvement of social welfare (as higher income or larger consumption) can be enjoyed earlier.
- But several factors can constrain technology adoption; partly results of market failures.
- Governments mainly pursue two general strategies:
  - Information provision
  - Provision of subsidies and support programs

    (output, input and credit subsidies, the provision of complementary infrastructure, and risk-reducing programs)

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Diffusion and adoption process of innovations in agriculture

Risk considerations (Feder & Umali, 1993; Sunding & Zilberman, 2001)

- Adoption of a new technology may expand the amount of risk associated with farming.
- Operators are uncertain about the properties and performance of a new technology, and these uncertainties interact with the random factors affecting agriculture.
- farmer's perception of yield risks is an overestimation of the true risks
- several <u>policy options</u> can be used to reduce the perceived risk and thus achieve optimal adoption: output price subsidy, subsidy on the cost per acre, per unit area subsidy…
- Reduction of risk through externalities associated with the <u>dissemination of information</u> (Early adopters provide information and learning that affects subsequent adopters)
- Mechanisms of <u>manufacturers</u> to reduce financial risks (warranty agreement, technical support system…)

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The agricultural innovation system in Germany
Short characterization (Bokelmann et al., 2012)

- Non-predictability of future as a characteristic of the development and introduction of complex innovations
- Success of innovation processes depends on trends on the market and in the society as well as on the behavior of key players in the innovation process
- Stronger uncertainty leads to need for higher information and consultation effort

-> Networks as an efficient answer to uncertainty

- Farmers as multipliers: demonstration projects lead to a reduction of the perceived risk for farmers who take over the innovation
- Role of functional adaptations and knowledge for successful introduction of complex innovations

The agricultural innovation system in Germany
Stakeholder specific remarks and recommendations
(Bokelmann et al., 2012)

Research institutions

- Strengthening applied research
- Incentives and appropriate measures for knowledge and technology transfer

(Machinery) suppliers

- Need for special, site specific requirements

-> no scale effects -> increased development risk vs. innovation

-> consequences on innovation promotion design

Farm consultancy system

- role for innovation has to be defined /optimized

The agricultural innovation system in Germany
Remarks and recommendations for political interventions
(Bokelmann et al., 2012)

- **System of meaningful indicators to evaluate** the agricultural innovation system should be set up.
- **Promoting transparency and consistency**:
  Legal framework and support programs can influence innovation in agriculture. Many offers need to be better known.
- Increase visibility and transparency of innovation and research funding programs and the possibilities of combination of funding measures
- communication and coordination between the "Projektträger"
- Consistency of promotion measures
- Adaptation of the innovation promotion measures to the specificity of the agricultural sector

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Energy efficiency as an example

Energy efficiency in agriculture (Germany)
Drivers of Energy Efficiency in Agriculture
(Meyer-Aurich et al., 2012)

- Main **drivers** for energy efficiency in agriculture:
  - farmers, their goals and their business philosophy; determined to a large extent by cost-price relationships and their impact on farmer’s income and welfare
  - Education and access to information
- Main **external drivers**:
  - economic and political environment
  - Governmental institutions, NGO and industries have an impact over the market or the propagation of en. efficiency in general.
- Specific impact of governmental institutions **with research funding of energy efficient technologies** in agriculture (funding lines especially from the BMEL, resulting in increased awareness and diffusion of new efficient technologies).

Energy efficiency in agriculture (Germany)
Potential impact and interest of stakeholders
(Meyer-Aurich et al., 2012)

- Energy efficiency in agriculture does not seem to be a very important issue for stakeholders involved.
- **Farmers' organizations** do not address the issue of en. eff. in agriculture to a significant extent. Energy is rather seen as a product they are selling than as a mean to produce.
- **Industry as supplier of machines**: needs to provide machines which comply with the farmers' goals.
  - Fuel as an issue for farmers
  -> innovations in more efficient engines are also in the interest of the industry
  - Rising awareness on en.eff. issues in the farmers' community
  -> stronger communication of industry suppliers concerning their energy consumption to the farmers and the public can be expected

Energy efficiency in agriculture (Germany)
Potential impact and interest of stakeholders
(Meyer-Aurich et al., 2012)

- **Governmental institutions:**
  the focus of energy efficiency policy is more on other sectors than agriculture until now.
- However the energy eff. in agriculture is getting more and more on the national agenda (e.g. research funding programs of the Federal Ministry of Agriculture)
- Impact of extension and advisory services: where they exist, they may have a substantial impact on the diffusion of innovations and funding programs within the aim of energy efficiency.
- **NGOs:** moderate to great interest in energy efficiency improving measures unless targets of nature conservation are affected.
  Their impact can be strong (e.g. debate on GHG in agriculture)

Precision Agriculture as an example

Why Precision Agriculture (PA) as an example?

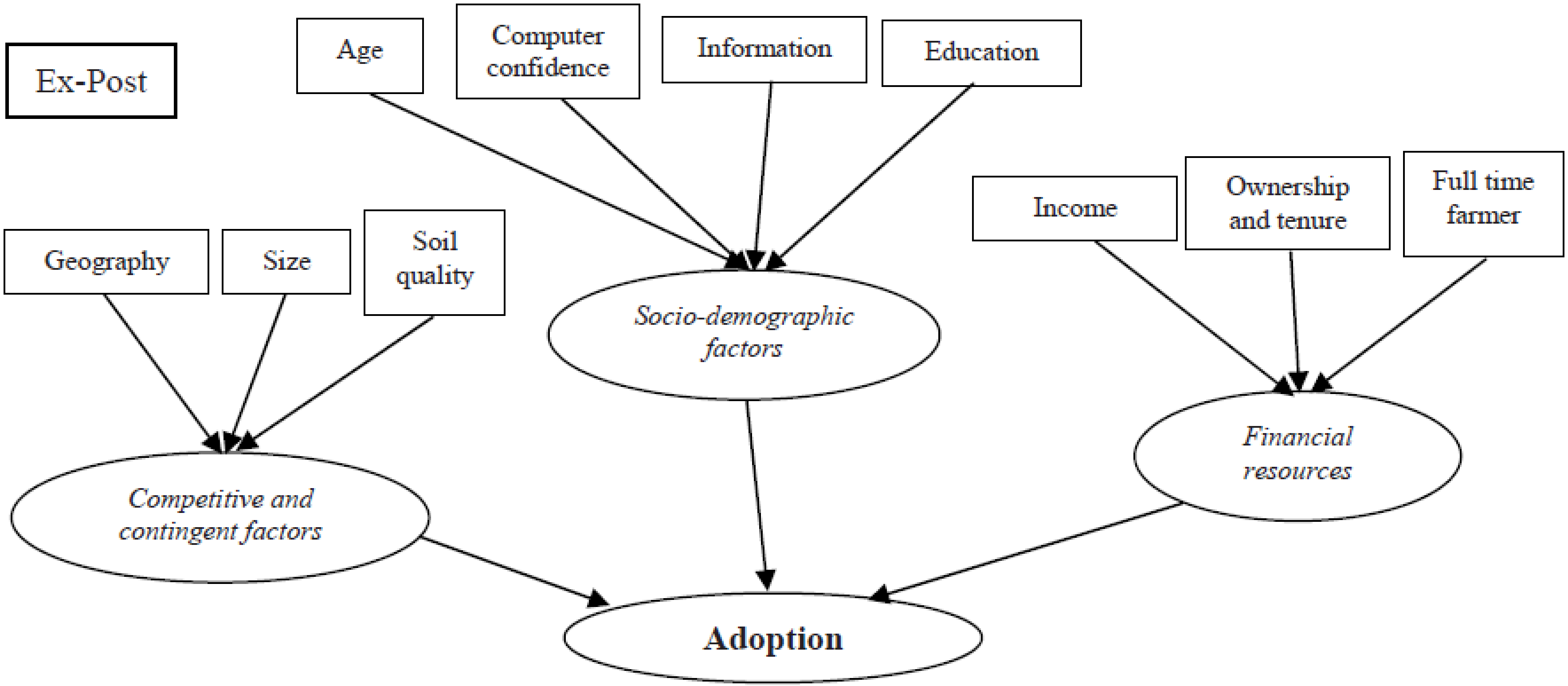
(Pierpaoli et al., 2013)

- Many research works on acceptance/adoption of precision agriculture.

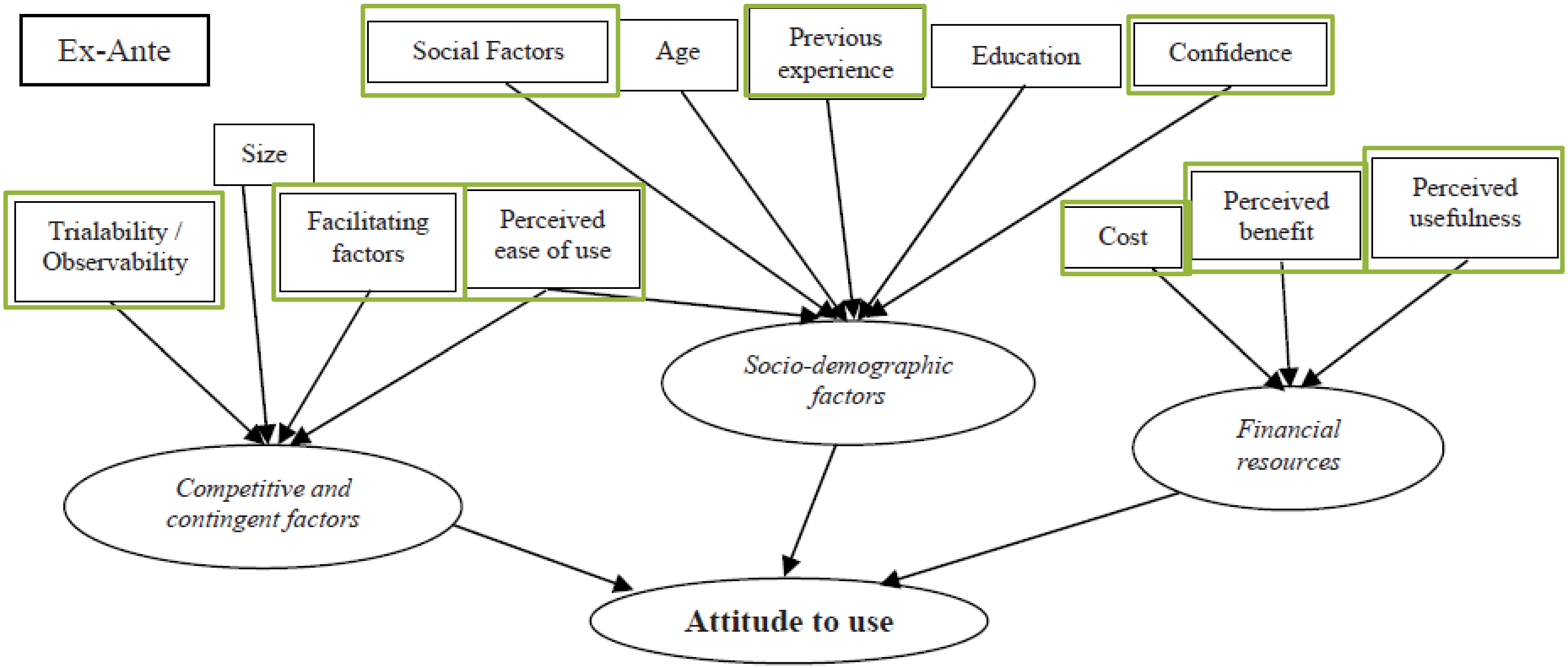
- Many aspects of PA have been studied, focusing on: relevant technologies, environmental effects, economic outcomes, adoption rates and drivers of adoption and non-adoption.
- Many authors have confirmed the environmental and economic benefits derived from PA.
- Nonetheless, a low rate of PA adoption is still reported by both academic surveys and professional reports.

Precision Farming as an example

Drivers of adoption (ex post) (Figure: Pierpaoli et al., 2013)



Precision Farming as an example
Drivers of adoption (ex ante) (Figure: Pierpaoli et al., 2013)



Precision Farming as an example
Drivers and constraints for investing in PA technologies
(Tinker & Morris, 2011)

- Profitability generally the main driver for investing in new equipment and systems, including PA technologies
- general levels and trends of investment in agricultural equipment are associated with the intensity, productivity and profitability of farming systems.
- present understanding of investment decisions by farmers remains incomplete, being relatively poorly researched.
- on the demand-side machinery purchases are influenced by financial and economic factors that affect the purchasing capability of farmers, the net cost of machinery acquisition and the relative gain from new and replacement investments in farm machinery.

Precision Farming as an example
Factors influencing investing in agricultural machinery
(Tinker & Morris, 2011; Pierpaoli et al., 2013)

- Factors influencing profit and hencing likelihood of investing in agricultural machinery <u>at broad scale</u>
  - commodity prices
  - labour prices
  - energy prices
  - environmental regulation
- Investment behaviour at the <u>individual farm level </u>is strongly influenced by individual farmer circumstances and motivation (e.g. associated with age, commercial orientation, tenure, inheritance and succession).
- These context specific factors may override the influence of external drivers.

Precision Farming as an example
Dealers' view concerning the barriers for investing in PA
(Holland et al., 2013)

- Detailed study on barriers to growth and expansion in precision agriculture examines customer as well as dealer and technology barriers (US context)
- Various customer issues create barriers (from the point of view of dealers)
- Numerous and various dealership centric issues of different importance can create barriers, among which the three most perceived are:
  - "the equipment needed changes quickly"
  - "finding employees"
  - "the fees we can charge are not high enough"

http://agribusiness.purdue.edu/files/resources/rs-11-2013-holland-erickson-widmar-d-croplife.pdf

Precision Farming as an example
Adoption of precision agriculture in Germany
(Busse et al., 2014)

- **Barriers for the adoption** of PA mainly appear in the later stages of the innovation processes:
- lack of financing for long-time validation and/or production
- low demand (mainly due to the lack of investment by farmers)
- insufficient communication/co-operation between actors
- knowledge transfer gap between science and practice

- **Important influencing factors** for the Precision Farming innovation field's innovation capacity and subsector plant production in Germany
  - political framework conditions (acts, standards, certifications and funding programs)
  - availability of a qualified labor force

Conclusion and outlook
What prevents us from using more efficient technology?

- **Factors** influencing the generation, diffusion and adoption processes of innovation / technology are numerous and various and interact with each other (complex system):
  - financial and economic factors
  - socio-demographic factors
  - competitive and contingent factors
  - political framework conditions (esp. regulatory and funding framework)
- Use of efficient technology vs. efficient use of technology
- A new technology can only be used in an efficient way if it **fits in the complex agricultural system**.
- **Life cycle** of agricultural machineries
- Resource efficiency means using more **knowledge** to use fewer resources (Ploetz et al., 2009)

References (I)

- Bokelmann, W., Doernberg, A., Schwerdtner, W., Kuntosch, A., Busse, M., König, B., Siebert,, R., Koschatzky, K., Stahlecker, T. (2012): Sektorstudie zur Untersuchung des Innovationssystems der deutschen Landwirtschaft. http://edoc.hu-berlin.de/oa/reports/reANMahiE9fW6/PDF/22Hcr8DEWhpBA.pdf
- Busse, M., Doernberg, A., Siebert, R., Kuntosch, A., Schwerdtner, W., König, B., Bokelmann, W. (2014): Innovation mechanisms in German precision farming. Precision Agriculture 15 (4), 403-426
- Feder, G., Umali, D. L. (1993): The Adoption of Agricultural Innovations A Review. Technological Forecasting and Social Change (43), 215-239
- Holland, J.K., Erickson, B., Widmar, D.A. (2013): Precision agricultural services dealership survey results (Under Faculty Review) Dept. Of Agricultural Economics, Purdue University, West Lafayette, Indiana 47907-2056, USA

References (II)

- Meyer-Aurich, A., Scholz, L., Ziegler, T., Jubaer, H. (2012): Country Report Germany – Stakeholder and Driver Analysis on Energy Efficiency in Agriculture. Project Deliverable 2.2. in the EU project agrEE
- Pierpaoli, E., Carli, G., Pignatti, E., Canavari, M. (2013): Drivers of Precision Agriculture Technologies Adoption: A Literature Review. Procedia Technology 8 (2013) 61-69
- Ploetz, C., Reuscher, G., Zweck, A. (2009): „Mehr Wissen - weniger Ressourcen" VDI Technologiezentrum (Hrsg.), Schriftenreihe Zukünftige Technologien Consulting Nr. 83, Düsseldorf
- Possas, M. L., Salles-Filho, S., da Silveira, J.M. (1996): An evolutionary approach to technological innovation in agriculture: some preliminary remarks, Research Policy, 25 (6), 933-945

References (III)

- Sunding, D., Zilberman, D. (2001): The agricultural innovation process: research and technology adoption in a changing agricultural sector. In: Gardner, B., Rausser, G. (eds.) Handbook of Agricultural Economics, Vol. 1, pp. 207-261
- Tinker, D.B., Morris, J. (2011): An assessment of the potential impacts of the 2013 CAP reform on the Agricultural Machinery Industry. Report prepared for CEMA – European Agricultural Machinery Association (restricted circulation)

CO_2 quantification for agricultural machinery in the EU

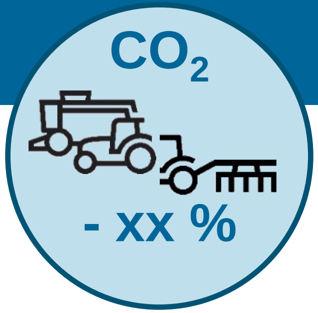
Results of the concept study

VDMA Team CO_2

Beate Fleck, Steffen Hanke

Braunschweig, 11.03.2015

Agenda



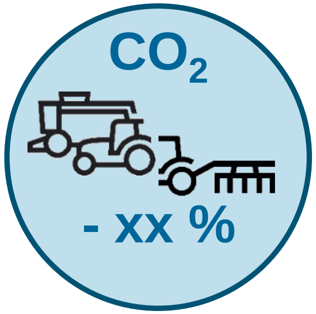
1. Motivation

2. Approach for voluntary commitment
   - Finalise concept description
   - Pre-clarification of typical farm concept
   - Identification of technological CO_2 saving potentials
   - Concept of modular modelling
   - Concept specification for an official verification procedure

3. Conclusion

MOTIVATION

Need for action to achieve the environmental and climate goals



What are the requirements?

- Reaching the EU climate objectives
- Manufacturers want to and must make their contribution
- A holistic approach with focus on process chains
- Alternative to regulatory measures
- Emission reduction reached by competition-driven innovations as well as by cooperation
- Identification of research necessities

[Amazone]

[CLAAS]

Agenda

CO_2

- xx %

1. Motivation

2. Approach for voluntary commitment

   - Finalise concept description
   - Pre-clarification of typical farm concept
   - Identification of technological CO_2 saving potentials
   - Concept of modular modelling
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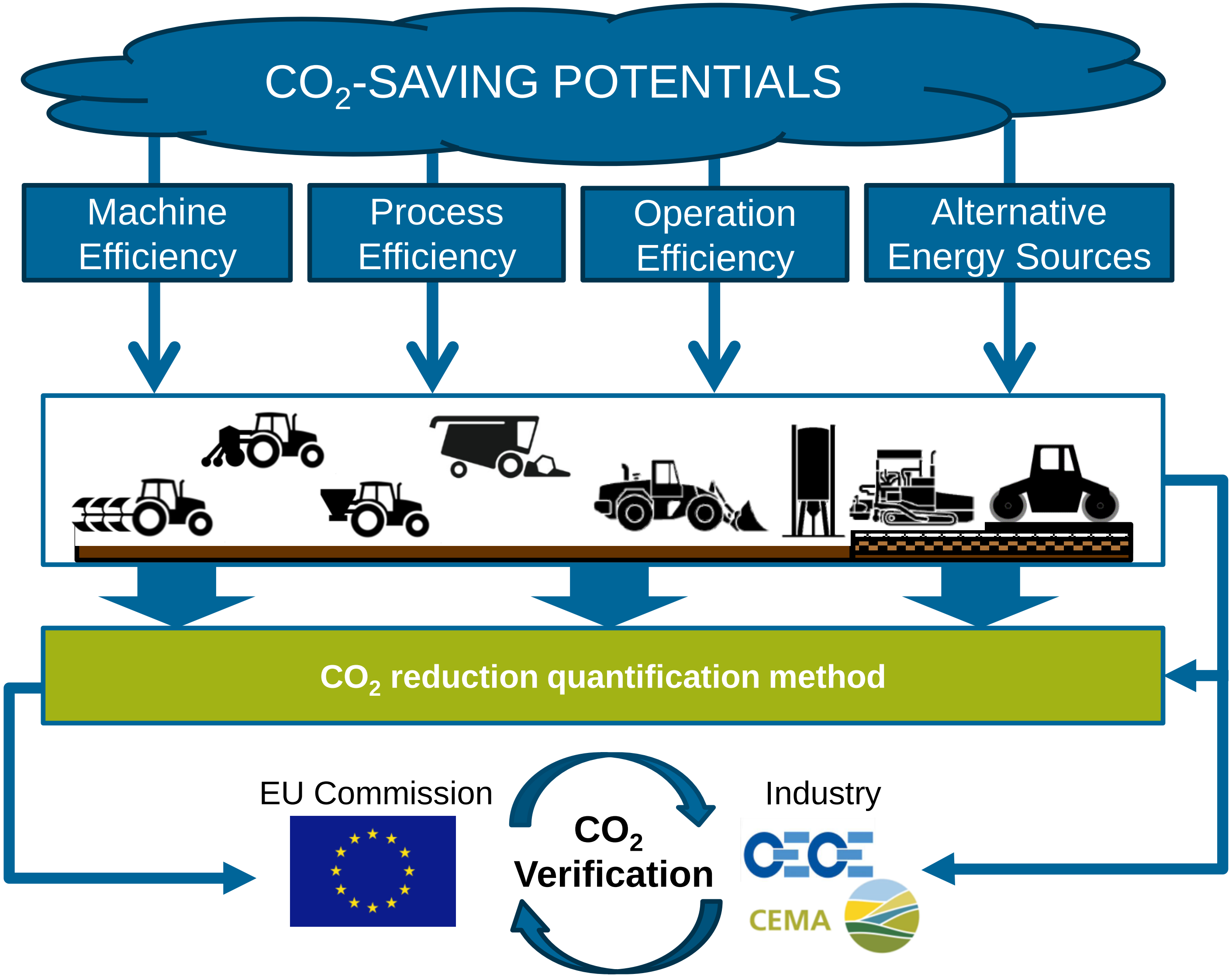
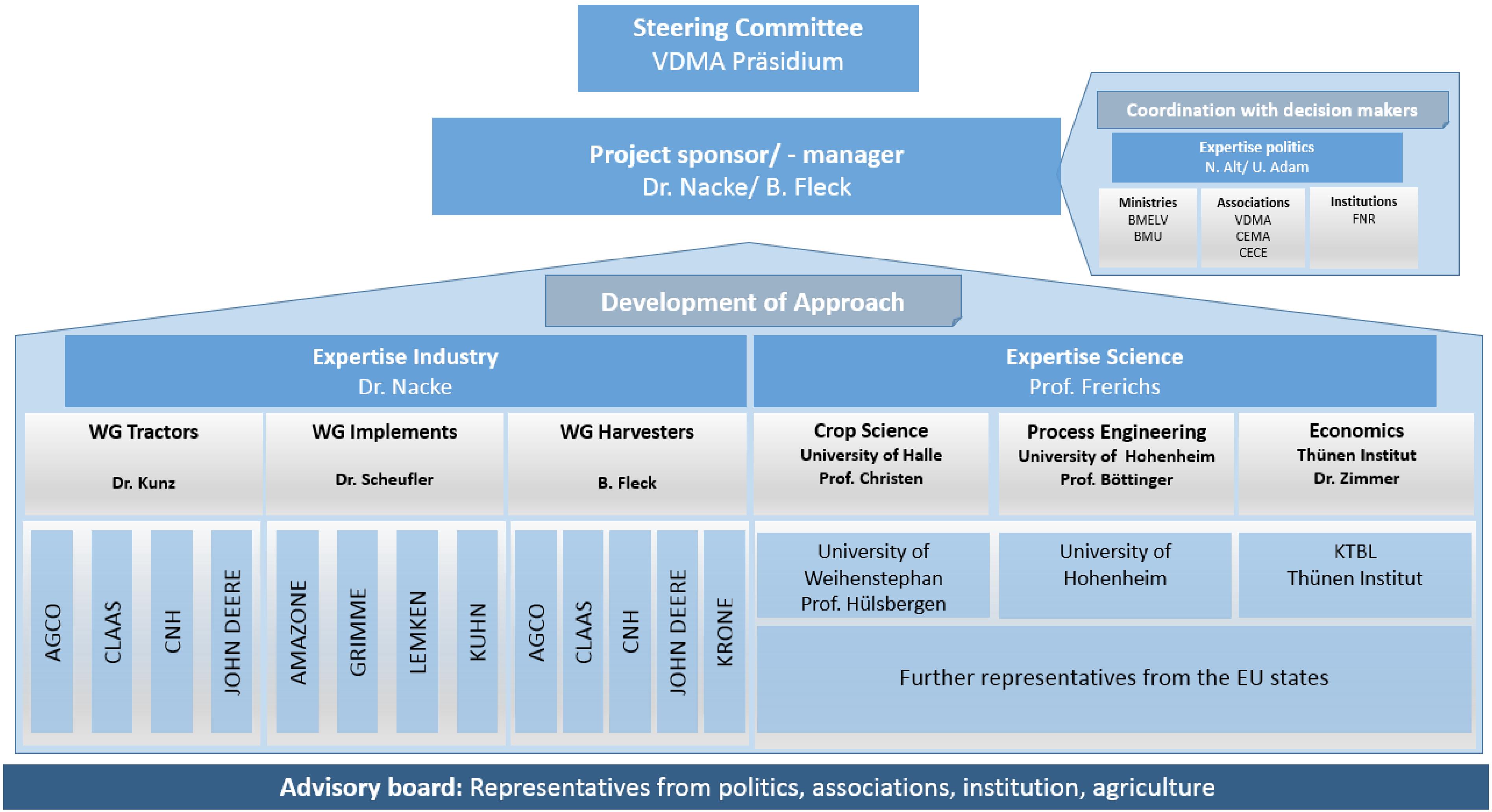
3. Conclusion

Basic approach of modelling and simulation

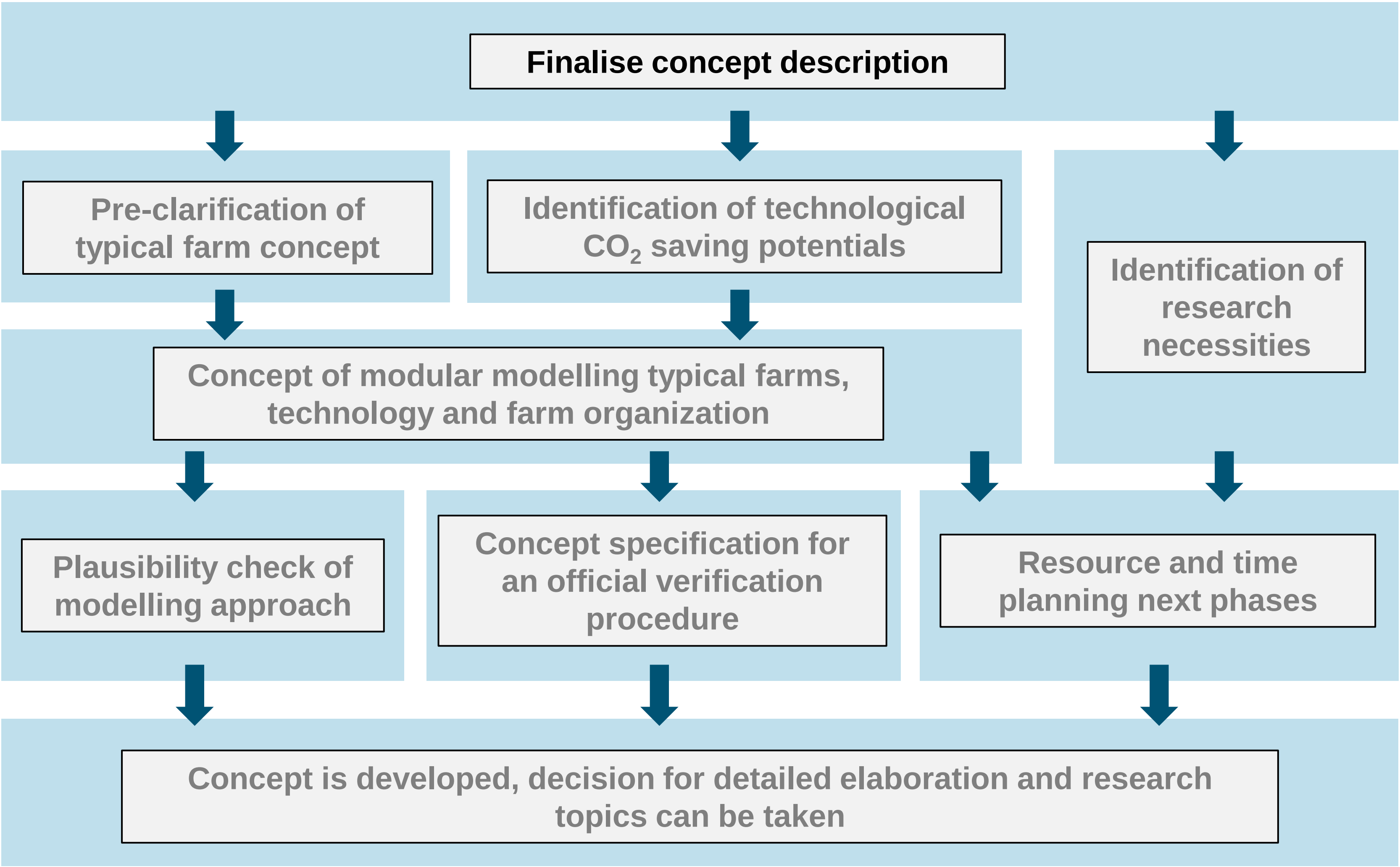


APPROACH
Project structure



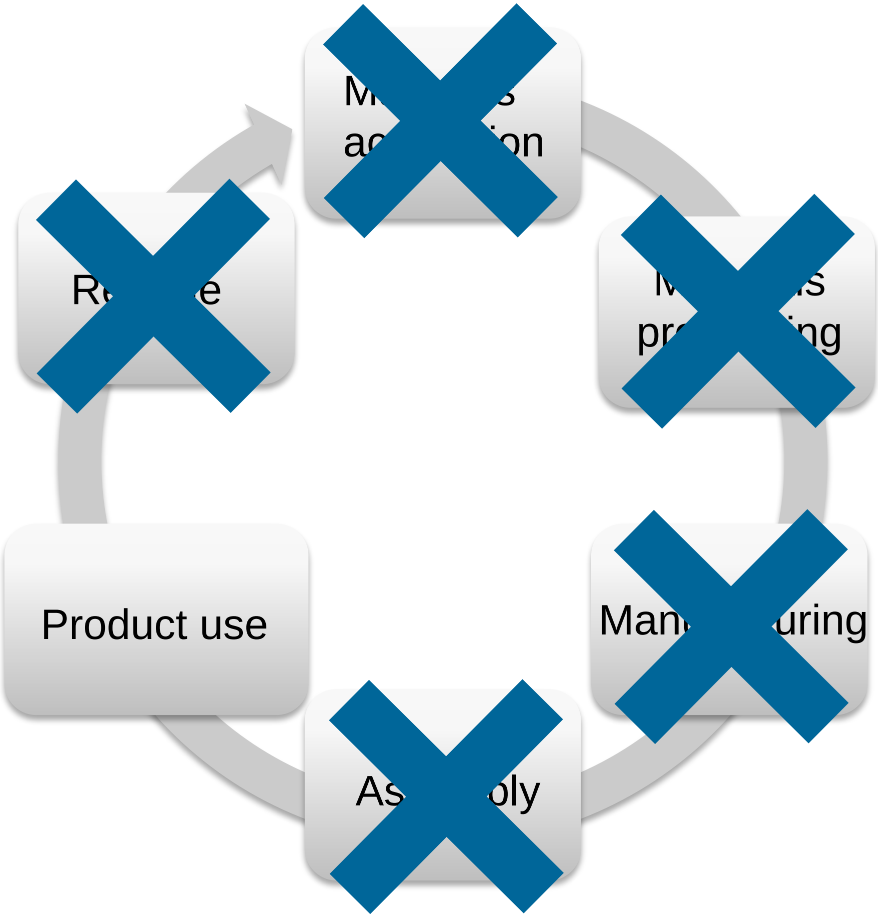
APPROACH

Phase 2: Specification of the concept (12 months)



APPROACH

System boundaries – No Life Cycle Assessment (LCA)



CO_2 emissions:

- Focus on machine in operation
- Focus on fuel consumption
- No operating resources like fertilizer

System boundaries – Countries and crops

- Definition of typical farms in 7 countries
- 3 crops to cover about 80 % of agricultural area in EU 28

[CLAAS]

Grain

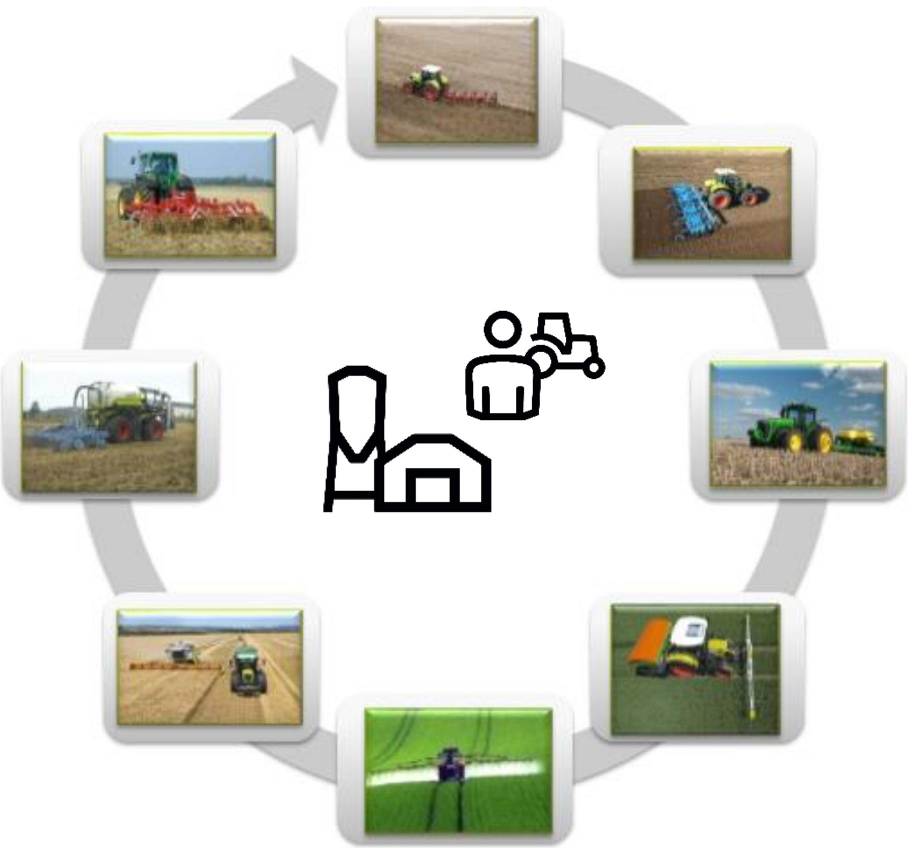
[CLAAS]

Corn

[CLAAS]

Grassland

System boundaries – process chain, machines, comparison unit



Definition of process chain

- Structure model farm
- Technology in use
- Organization

Machinery in use

- Travel distances

  "farm – field – farm" and "field – field"
- Transport of production unit to

  on farm storage

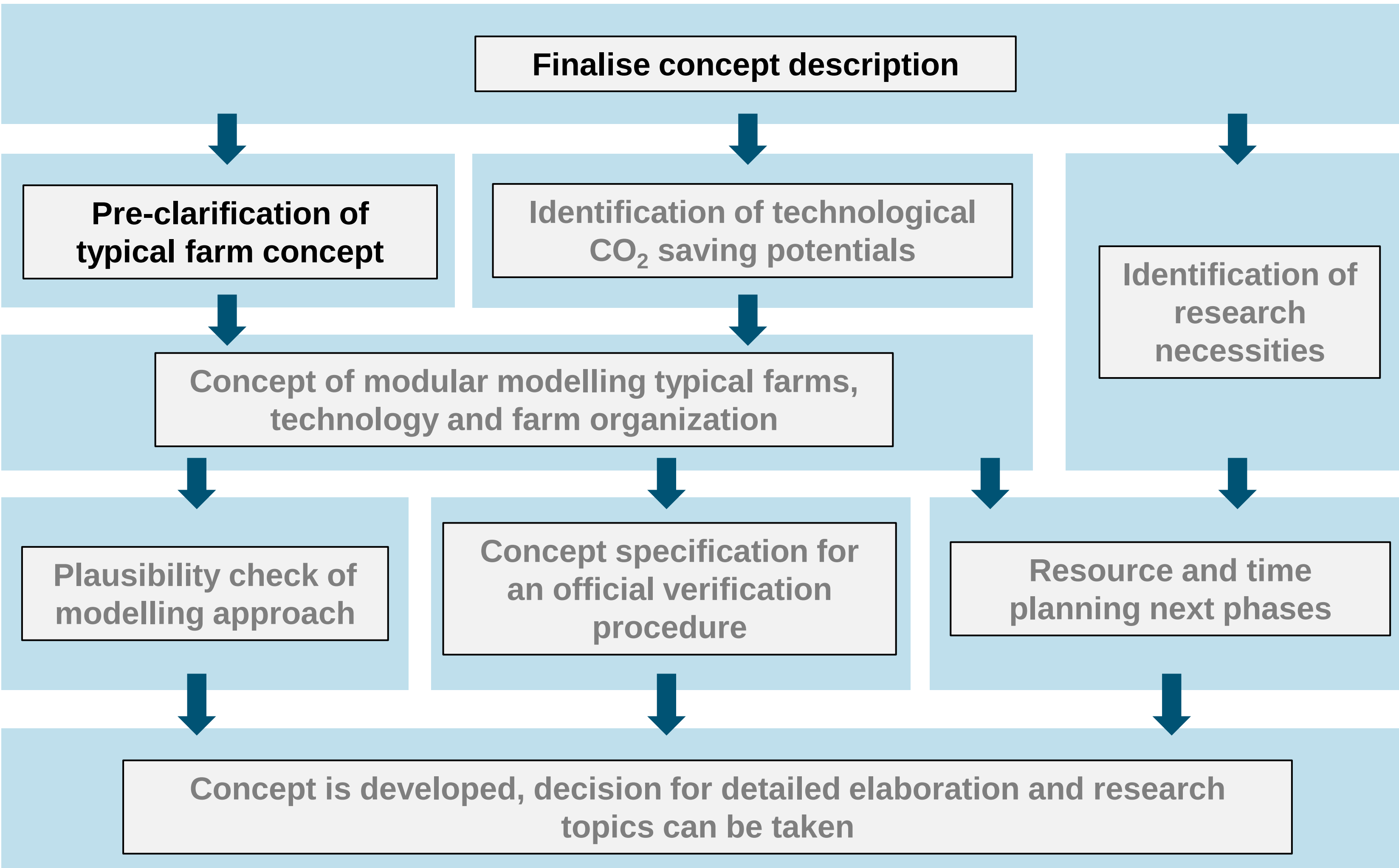
Comparison unit

- kg CO_2 / t GE

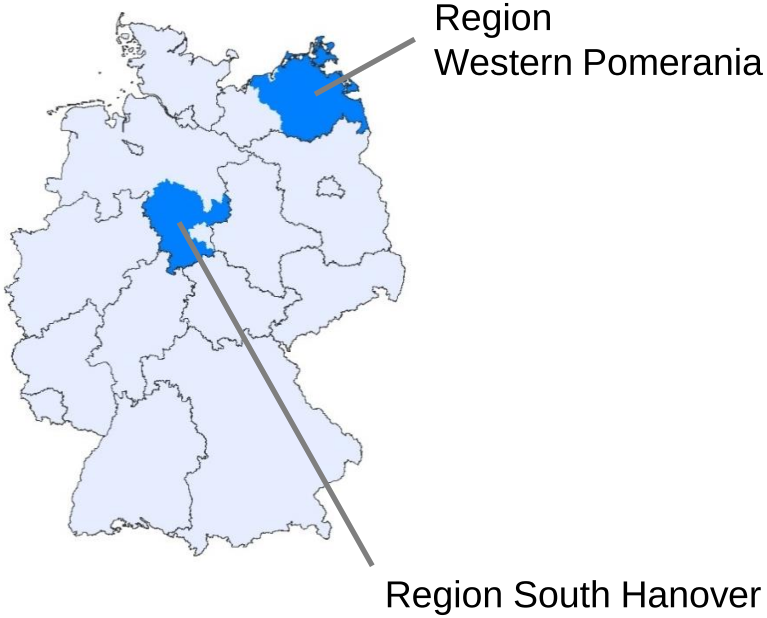
  (GE: Grain equivalent unit; 1 GE = 107 kg wheat)

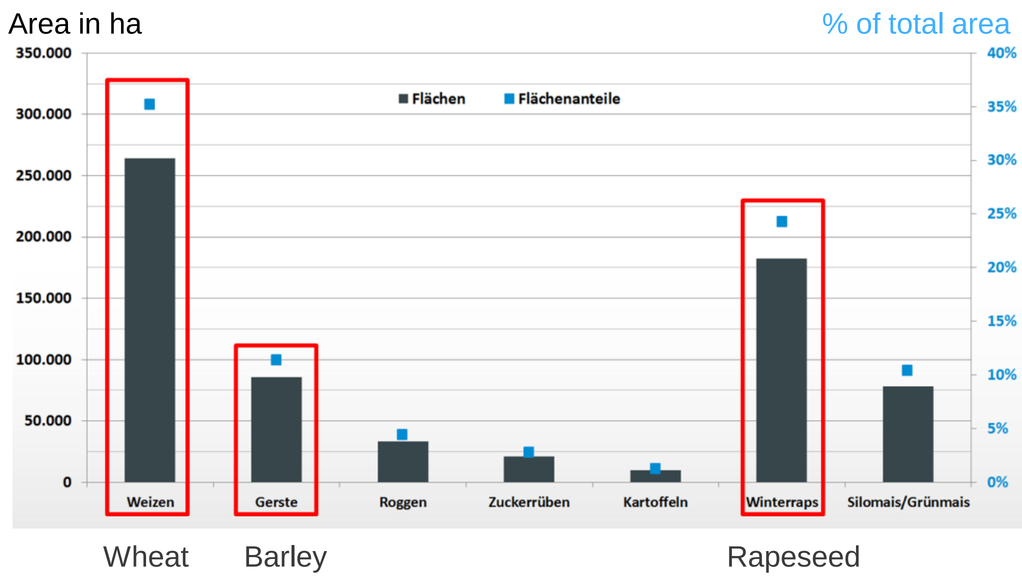
APPROACH

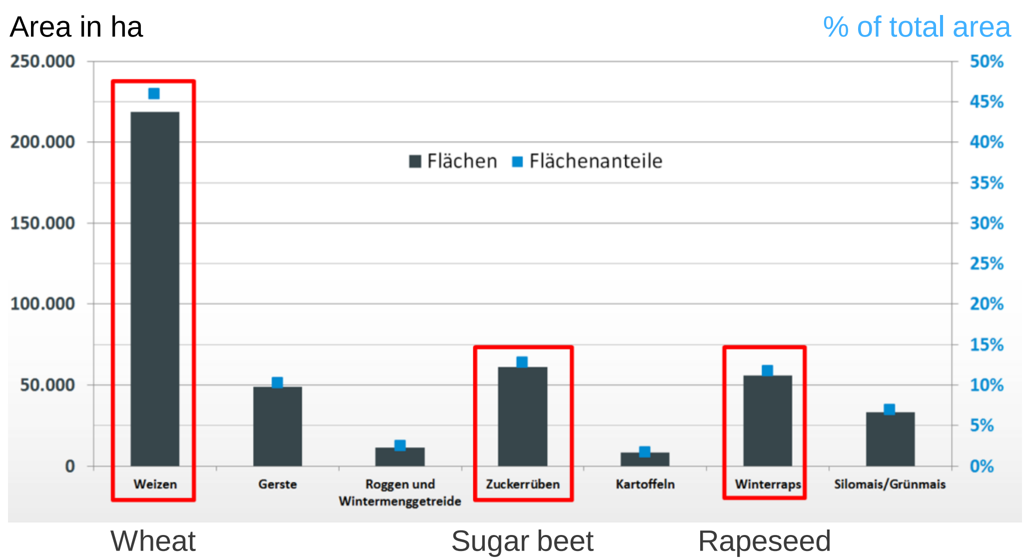
Phase 2: Specification of the concept (12 months)



Pre clarification of typical farm concept







Pre clarification of typical farm concept

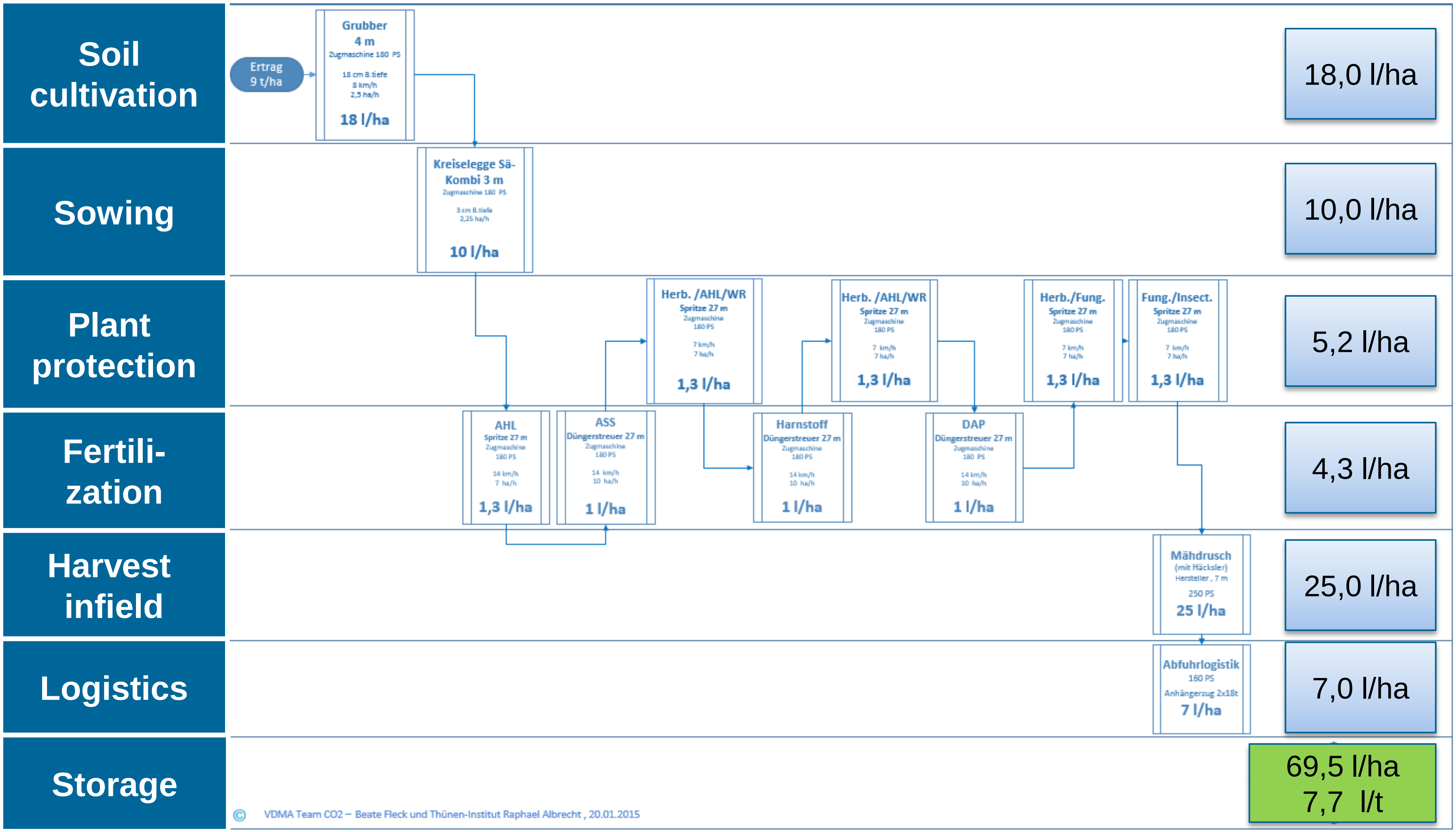
Farm structure | 2014

Category	Western Pomerania (DE1100VP)	South Hanover (DE150SH)
Arable land in ha	1.100	150
Total annual precipitation in mm	490	650
Soil quality classification (max. 100)	41	85

Machines in use | 2014

Category	Western Pomerania (DE1100VP)	South Hanover (DE150SH)
Tractors	4 T. | hp 150 to 360	3 T. | hp 110 to 180
Combine (working width in m)	1 C. (12 m) 2 C. (9 m)	1 C. (7 m)
Soil cultivation (working width in m)	1 Compact disc harrow (6,5m) 1 Mulch cultivator (4,5 m)	1 Plough 1 Mulch cultivator (4 m)

Pre clarification of typical farm concept | example process chain



Pre clarification of typical farm concept

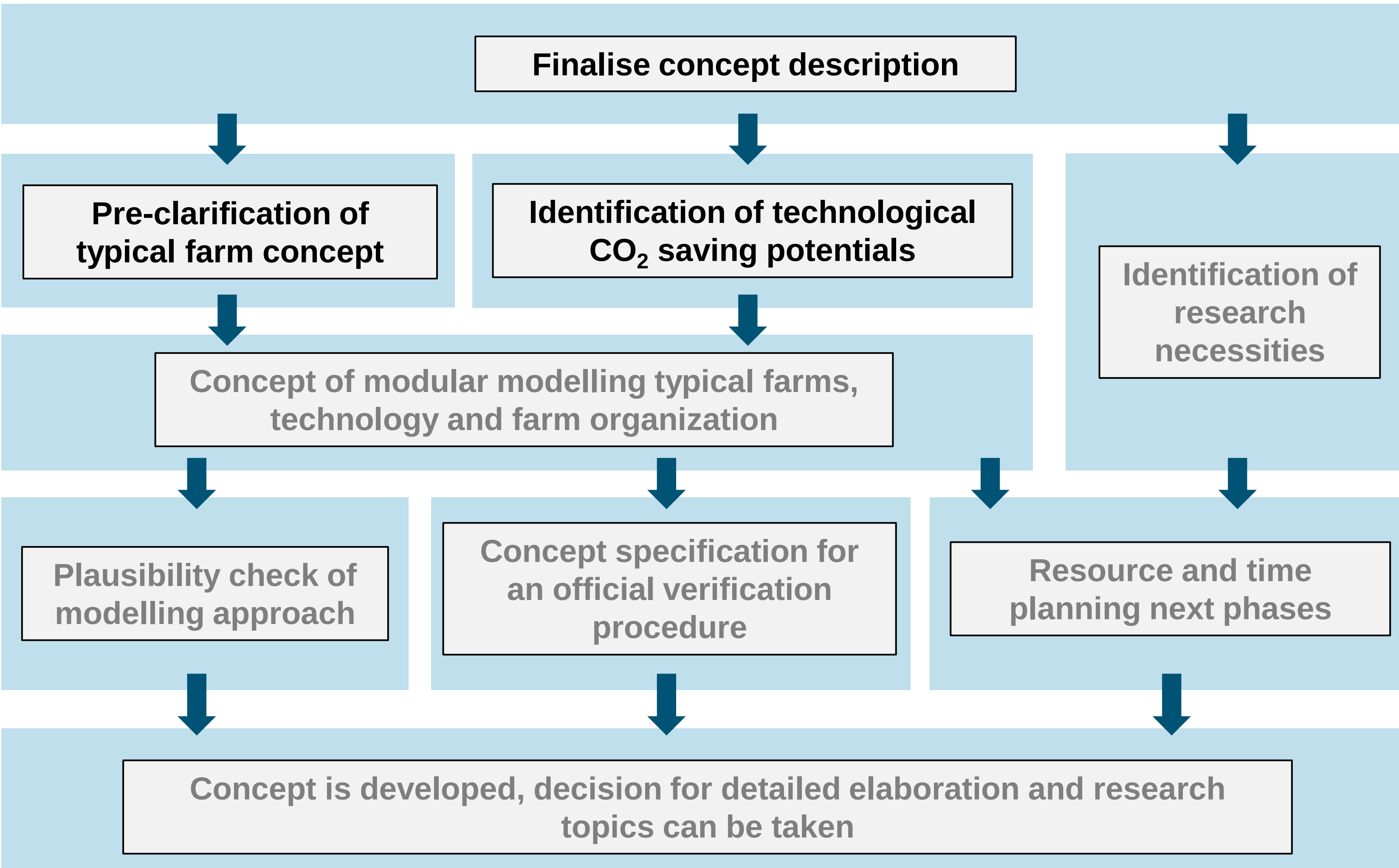
Fuel consumption l/t | 2012 – 2014 | depending on crop rotation

Crop rotation	Western Pomerania (DE1100VP)		
Wheat after wheat	75 l/ha | 7,8 t/ha = **9,6 l/t**	25,6 kg CO2/t	100%
Wheat after rapeseed	59 l/ha | 8,6 t/ha = **6,9 l/t**	18,4 kg CO2/t	- 28%
Wheat after silage maize	68 l/ha | 8,0 t/ha = **8,5 l/t**	22,7 kg CO2/t	- 11%

Crop rotation	South Hanover (DE150SH)		
Wheat after sugar beet	63 l/ha | 9,0 t/ha = **6,9 t/ha**	18,4 kg CO2/t	100%
Wheat after wheat	77 l/ha | 8,5 t/ha = **9,0 t/ha**	24,0 kg CO2/t	- 30%
Wheat after rapeseed	72 l/ha | 9,0 t/ha = **8,0 t/ha**	21,4 kg CO2/t	- 16%

APPROACH

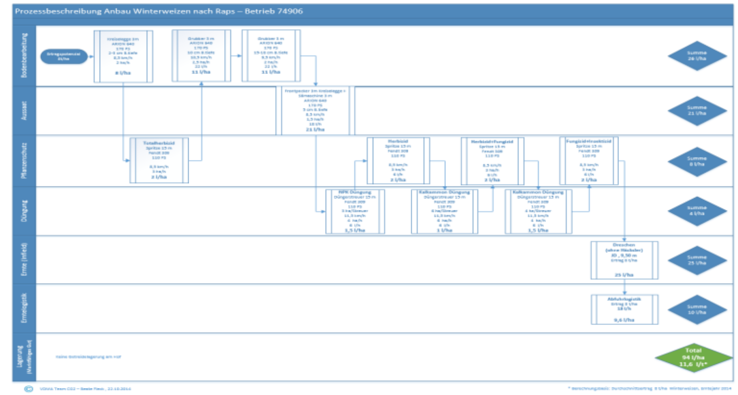
Phase 2: Specification of the concept (12 months)



CO_2 saving potentials

- **Focus groups agricultural experts:**

  Definition of process chain and machines in use



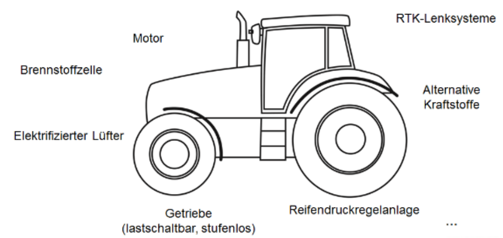
- **Focus groups agricultural engineering experts:**

  Definition of saving potentials

  Prioritization

  Quantification

Welche Baugruppen bzw. welche Technologien haben auf den Kraftstoffverbrauch bis ins Jahr 2030 einen Einfluss?



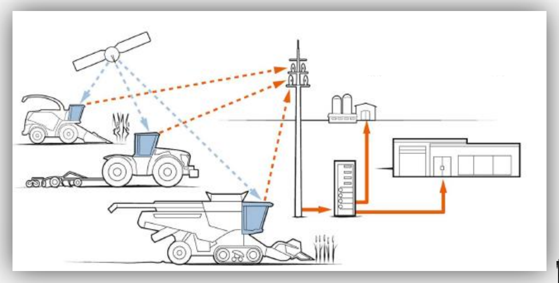
Welche Einflussfaktoren werden in naher Zukunft serienreif sein und vom Verbraucher angenommen?

Einflussfaktor	Einspar-potential	Mögliche Serienreife	Bewertung
Reifendruckregelanlage	🟢	🟢	
Getriebe	🟡	🟢	
Motor	🟡	🟢	
Elektrifizierter Lüfter	🟡	🟡	
...	🔴	🟢	
Alternative Kraftstoffe	🟢	🔴	
Brennstoffzelle	🟢	🔴	
...	🔴	🔴	

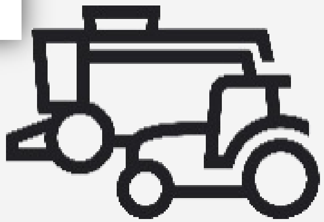
Haupteinfluss-faktoren

APPROACH
Examples | Future CO_2 saving potentials

Logistics (Fleet management)



GPS steering

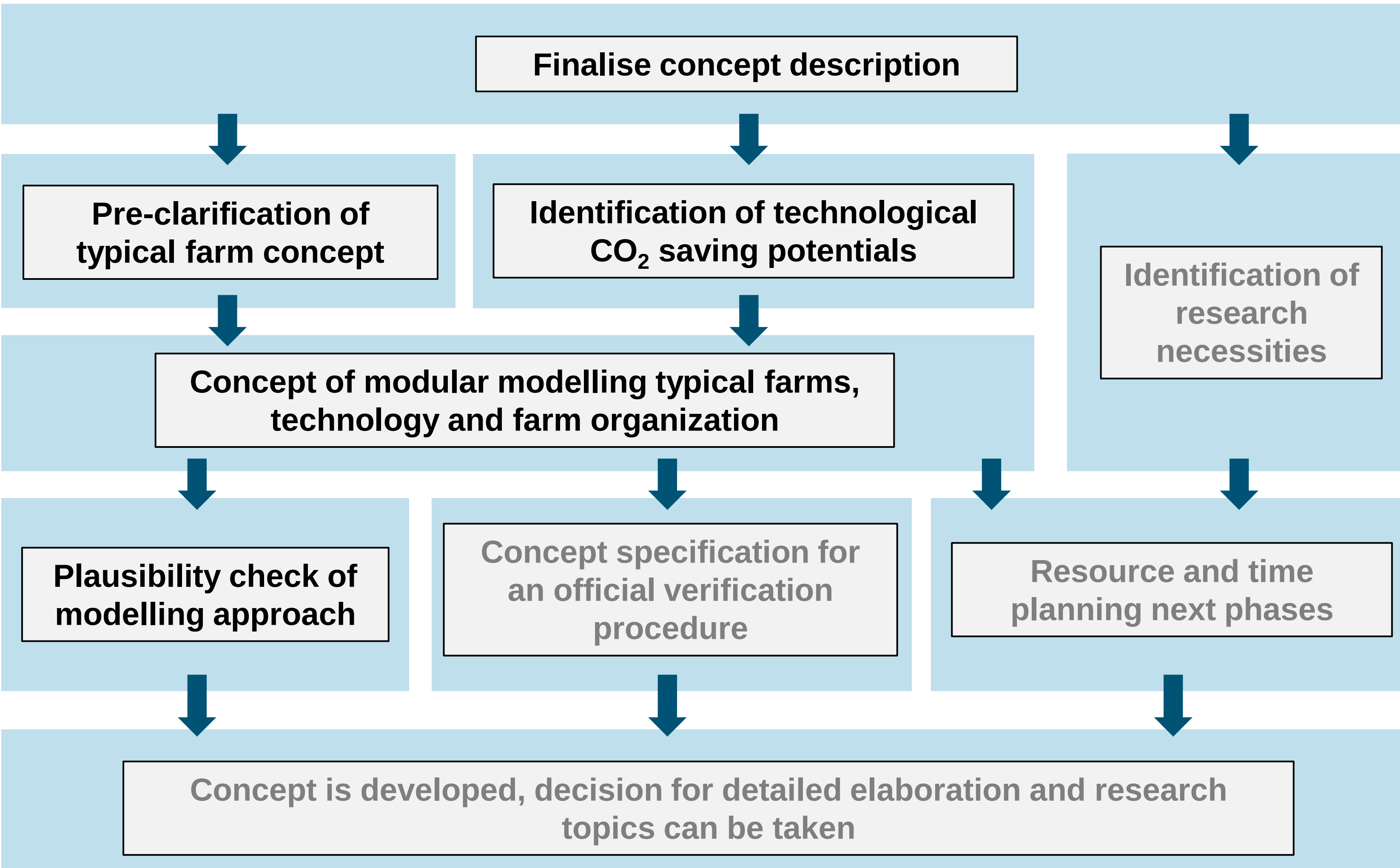


Assistance systems

Tyre inflation pressure control system

Bildquelle: [16,17,18,19]

Phase 2: Specification of the concept (12 months)

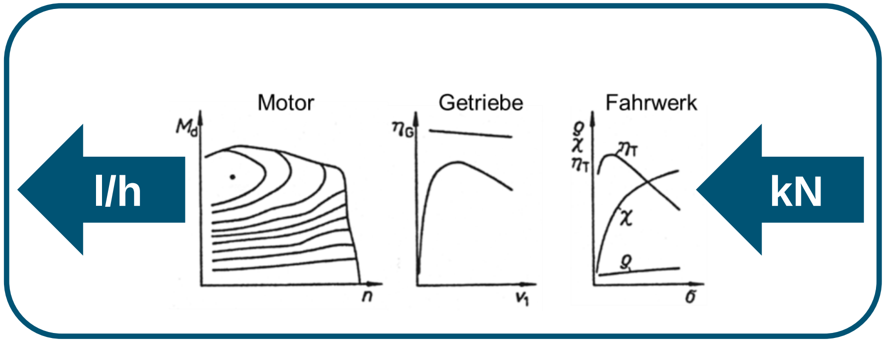


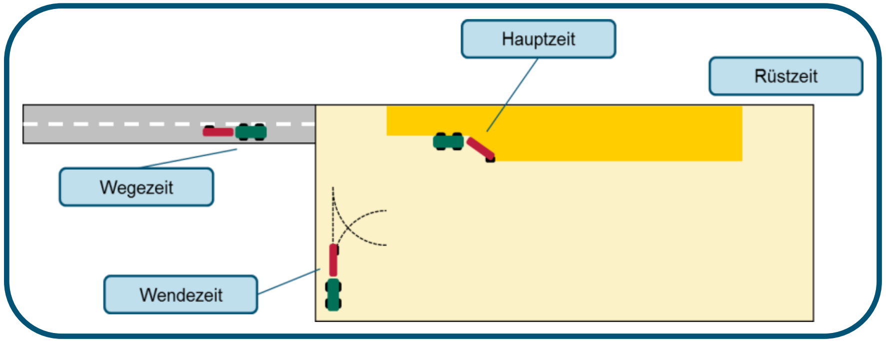
Fuel consumption calculation

Calculation with partial times (ASABE, Sonnen, Steckel, Schreiber, …)

Fuel consumption [l] = ∑ (time-related fuel consumption[l/h] x partial times[h])

eg. plowing

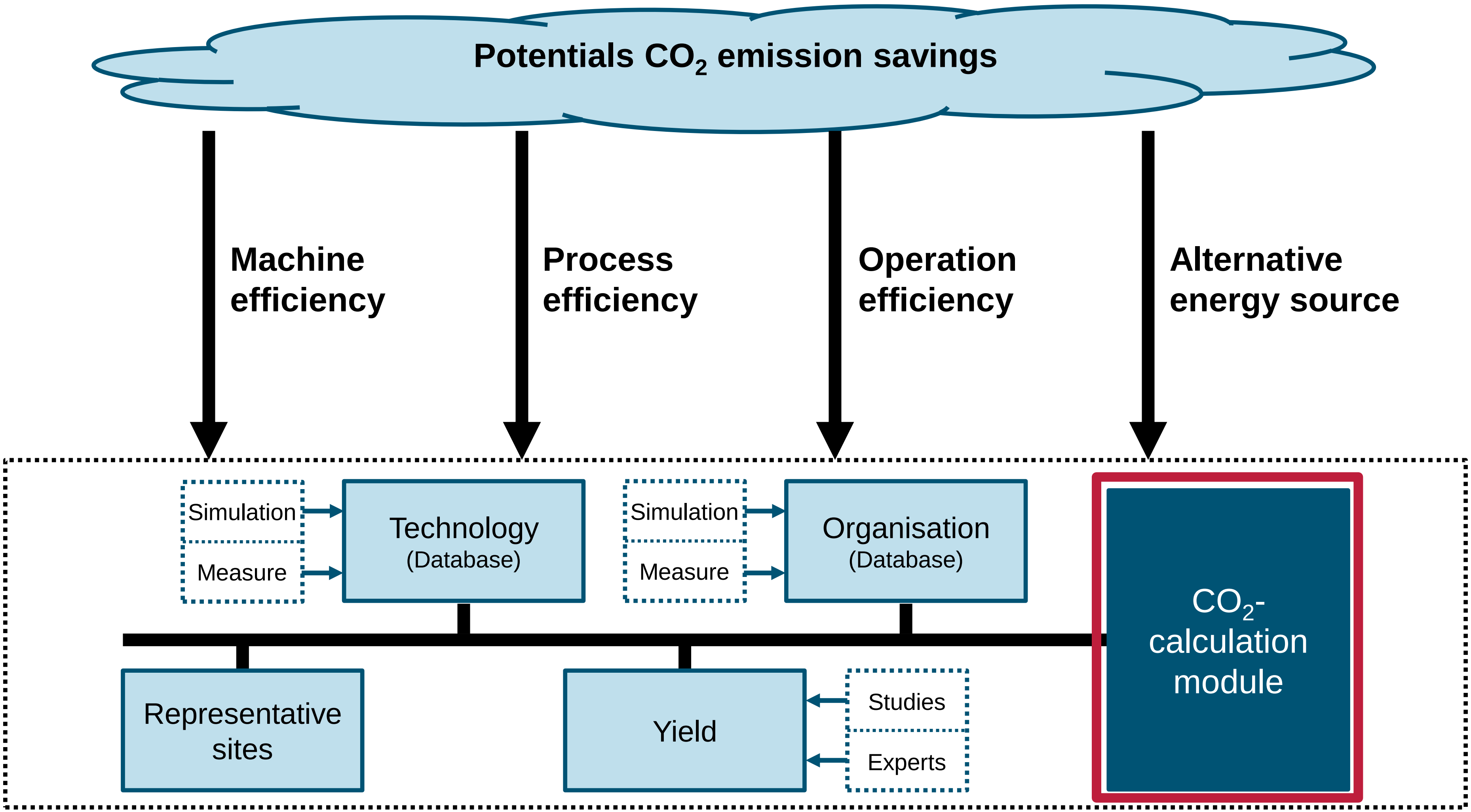




Conversion factor: 2,67 kg CO_2/l Diesel *

* [DIN EN 16258]

The modular simulation design



APPROACH

Definition of typical process chains and simulation results

Process step	Fuel consumption
Soil cultivation	18,0 l/ha
Sowing	10,0 l/ha
Plant protection	5,2 l/ha
Fertili-zation	4,3 l/ha
Harvest infield	25,0 l/ha
Logistics	7,0 l/ha
Storage	69,5 l/ha 7,7 l/t

Ertrag 9 t/ha

Grubber 4 m Zugmaschine 180 PS 18 cm B.tiefe 8 km/h 2,5 ha/h 18 l/ha

Kreiselegge Sä-Kombi 3 m Zugmaschine 180 PS 3 cm B.tiefe 2,25 ha/h 0 l/ha

Grubber 4 m Zugmaschine 180 PS

Herb. /AHL/WR Spritze 27 m

Herb. /AHL/WR Spritze 27 m

Herb./Fung. Spritze 27 m Zugmaschine 180 PS 7 km/h 7 ha/h 1,3 l/ha

Fung./Insect. Spritze 27 m Zugmaschine 180 PS 7 km/h 7 ha/h 1,3 l/ha

27 m Zugmaschine 180 PS 14 km/h 7 ha/h 1,3 l/ha

Mähdrusch (mit Häcksler) Hersteller, 7 m 250 PS 25 l/ha

Abfuhrlogistik 160 PS Anhängerzug 2x18t 7 l/ha

Only tillage
-1,7 l/ha
(- 10 %)

Total chain
- 2,4 l/ha
(- 4,4%)

Total chain
-0,9 kg CO_2/t GE
(- 4,4 %)

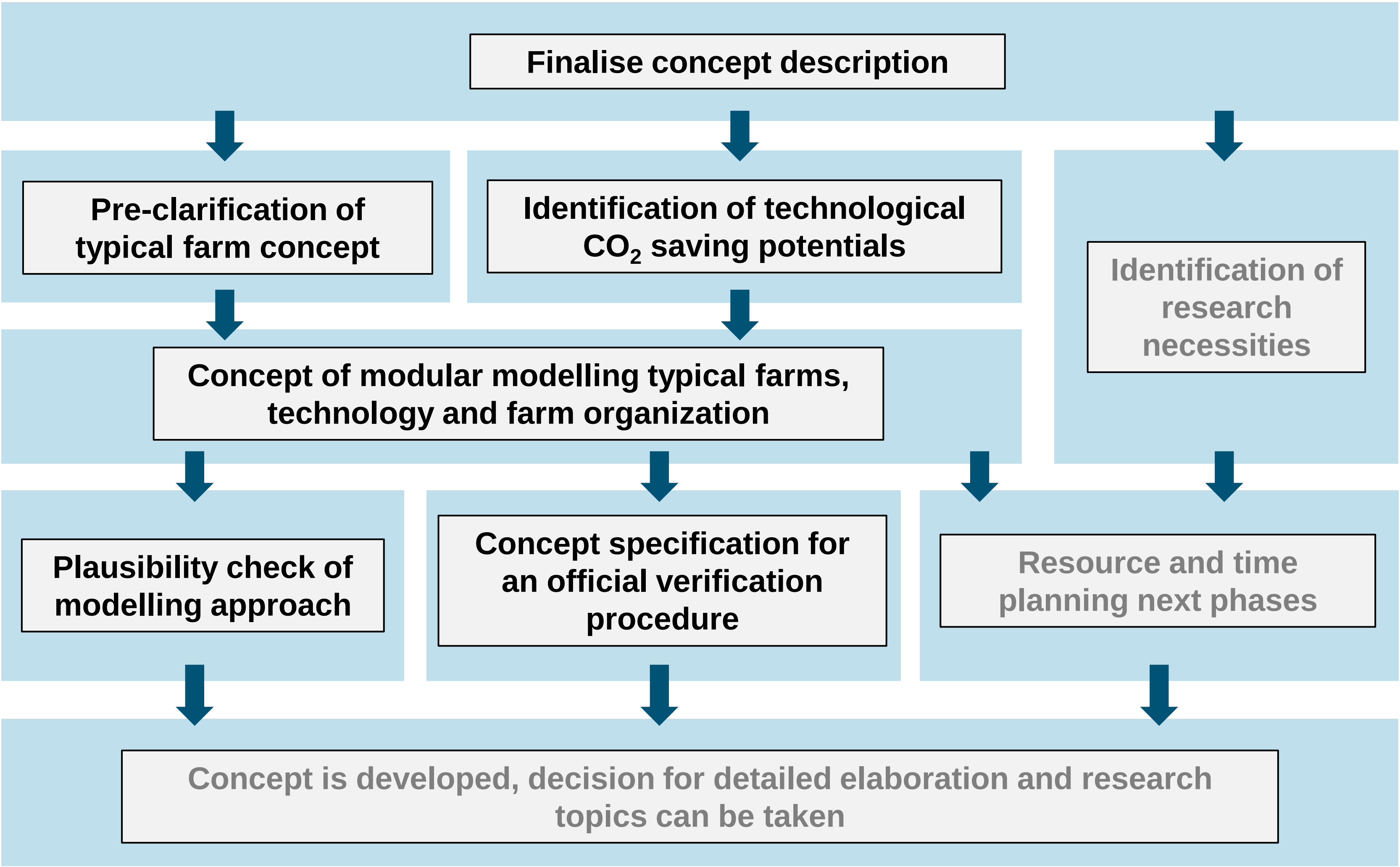
Tyre pressure control unit

[Fendt]

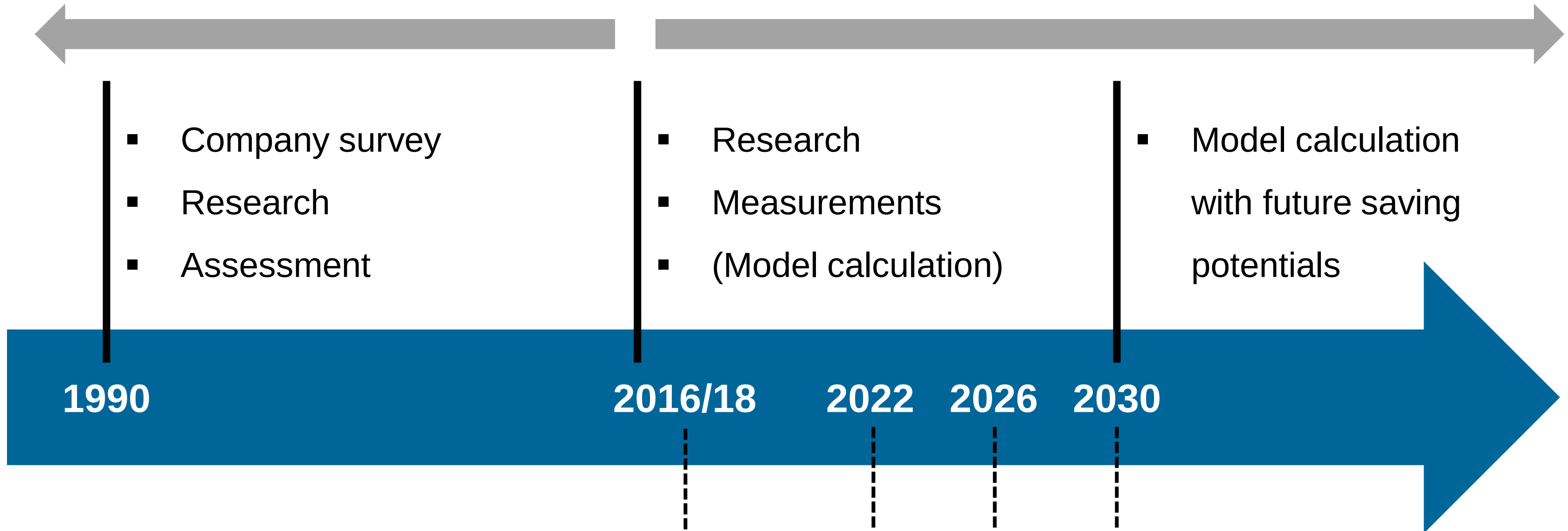
Total
20,6 kg CO_2/t

© VDMA Team CO2 – Beate Fleck und Thünen-Institut Raphael Albrecht, 20.01.2015

Phase 2: Specification of the concept (12 months)

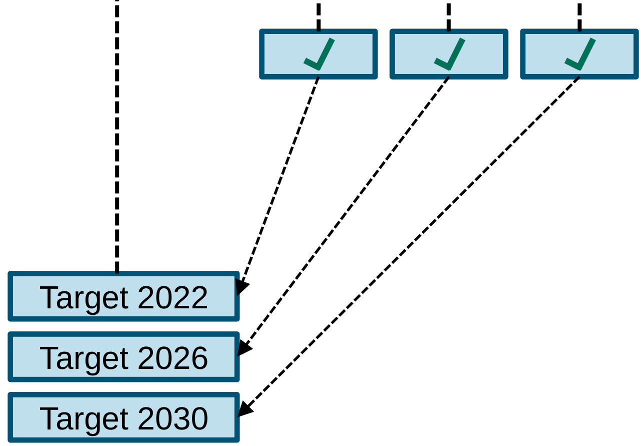


Determination of the CO_2 emissions along time and verification procedure



Verification of targets in 2022/26/30:

Basis: Model calculation with real saving potentials and committee of experts

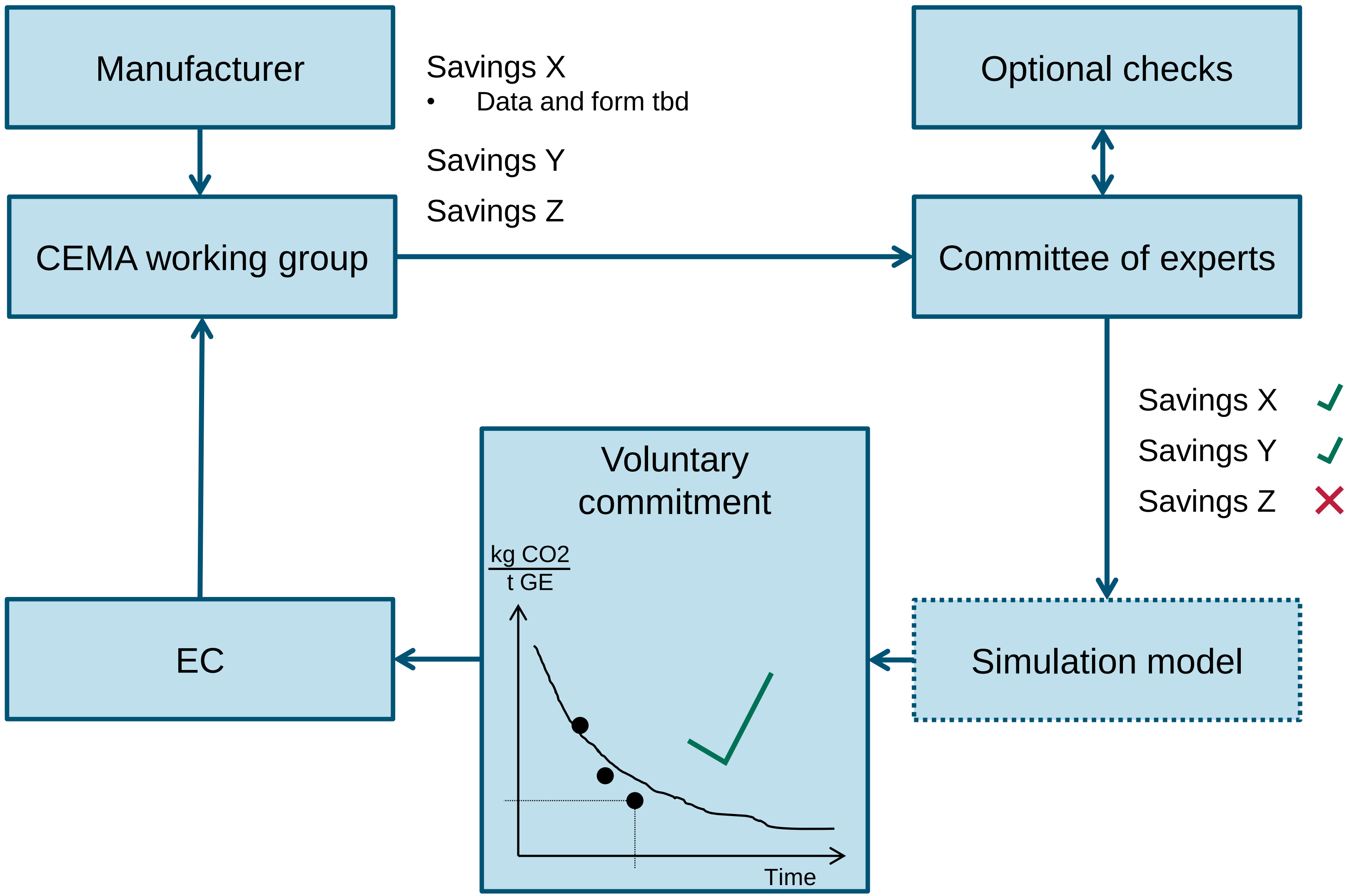


Targets from year 2016 … 2018:

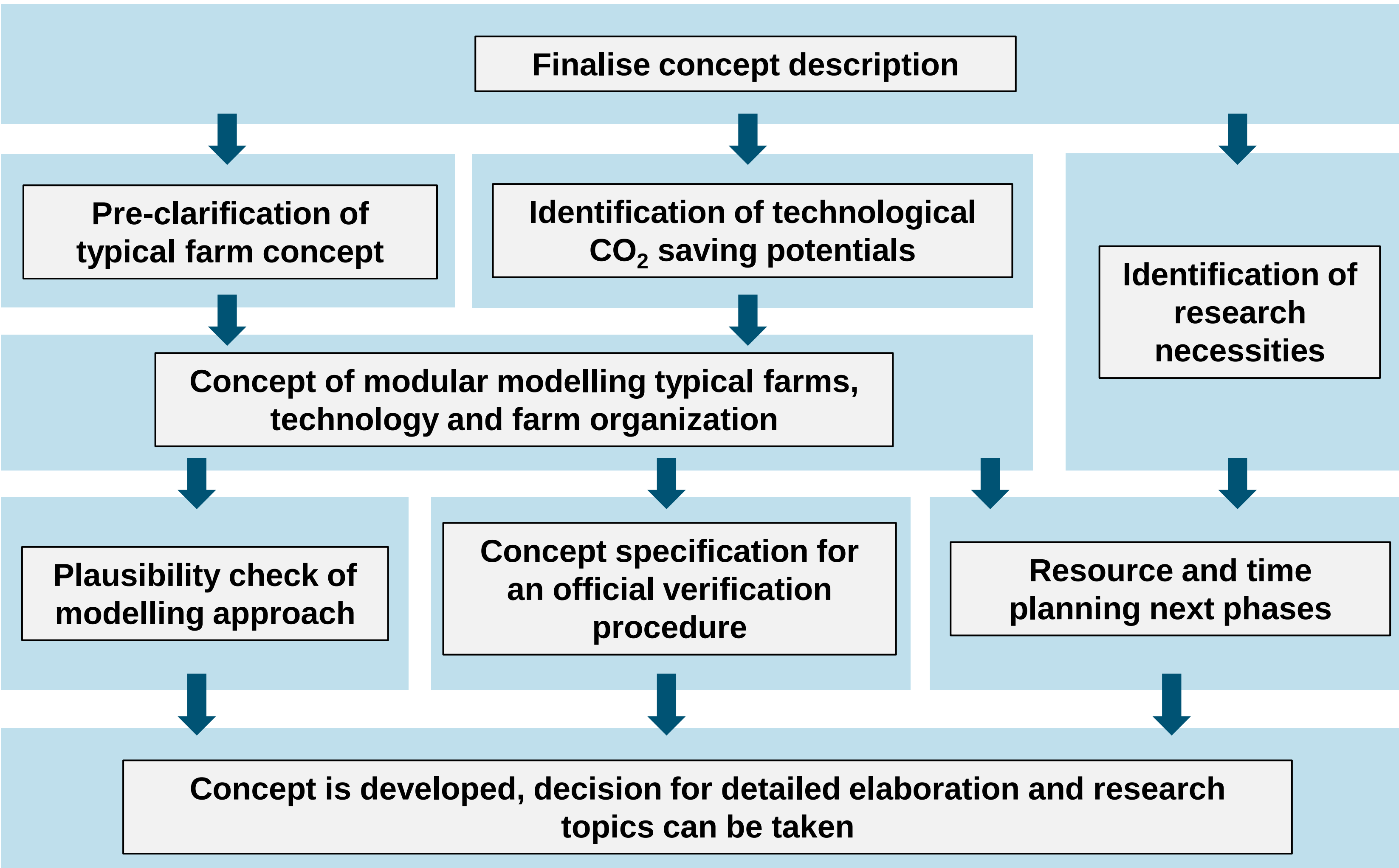
Basis: Model calculation with estimated saving potentials

Timing depends on agreements with EC

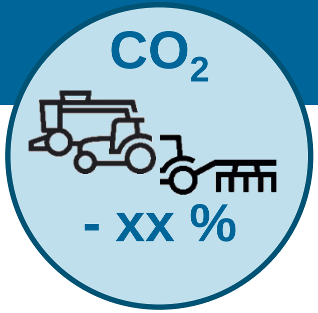
Overview of validation concept



APPROACH
Phase 2: Specification of the concept (12 months)



Agenda



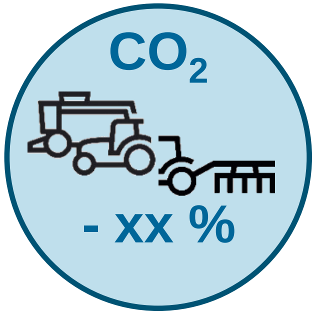
1. Motivation

2. Approach for voluntary commitment
   - Finalise concept description
   - Pre-clarification of typical farm concept
   - Identification of technological CO_2 saving potentials
   - Concept of modular modelling
   - Concept specification for an official verification procedure

3. Conclusion

CONCLUSION

Need for action to achieve the environmental and climate goals



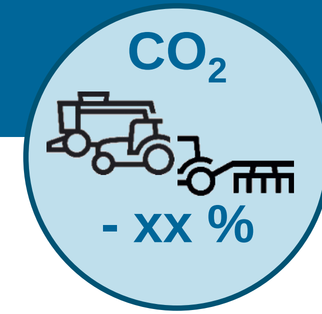
What we achieved so far?

- Concept including system boundaries is defined
- First concept validation with typical farms are made

How to continue?

- Active joint research work have to be done to quantify saving potentials
- Application for a research project
- Further detailed collaboration with the stakeholder

Conclusion
Many thanks for your attention!



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Karlsruher Institut für Technologie

LEHRSTUHL FÜR MOBILE ARBEITSMASCHINEN

CO_2 Quantification for Typical Mobile Machine Application Processes in Road Building, Earthmoving

Dipl.-Ing. Isabelle Ays / Prof. Dr.-Ing. Marcus Geimer

Institute of Vehicle System Technology (FAST), Chair of Mobile Machines (Mobima)
Director of the Institute: Prof. Dr.-Ing. Marcus Geimer

COMMITTEE FOR EUROPEAN CONSTRUCTION EQUIPMENT

Outline

I. CO_2- quantification method

II. Application on a representative example

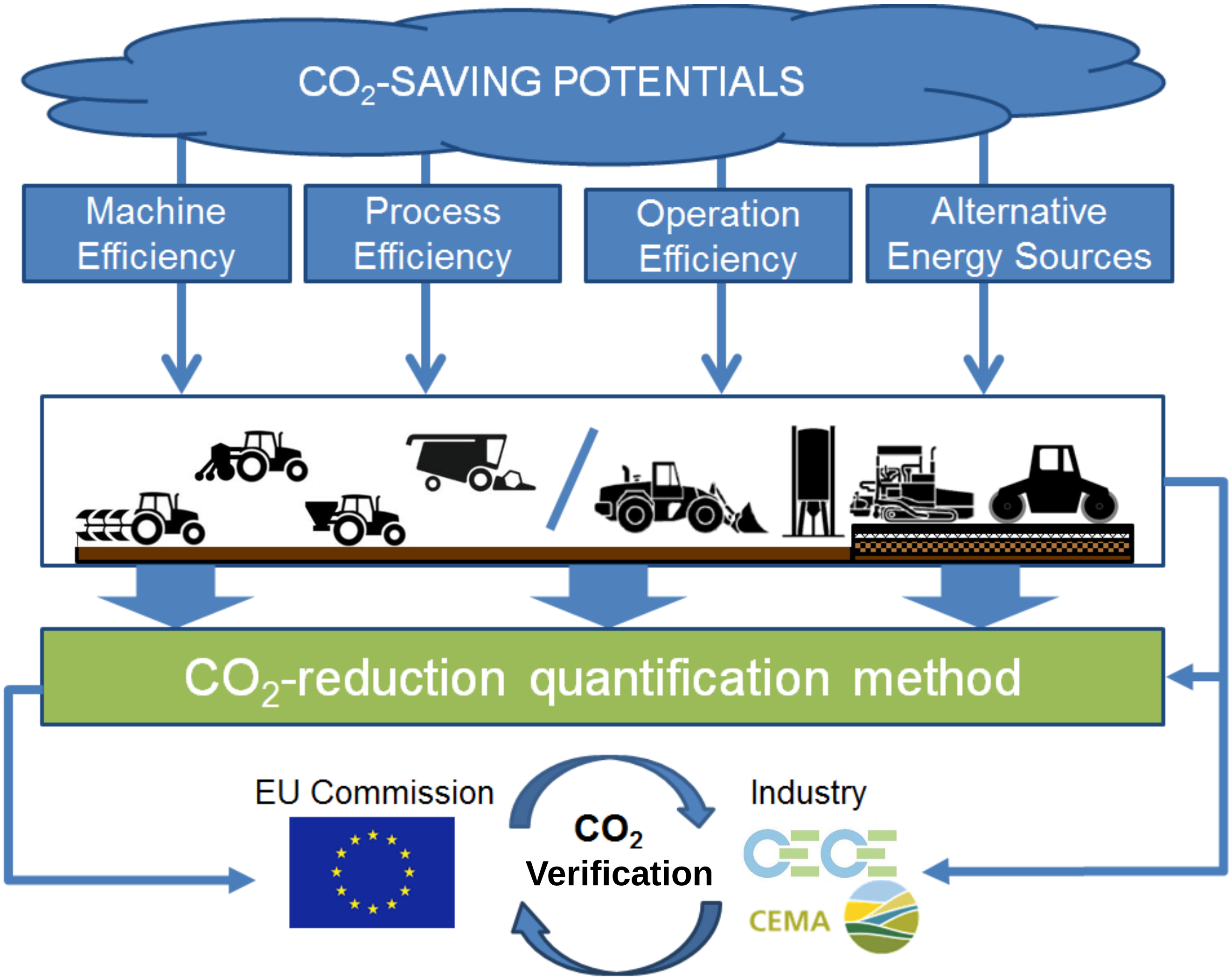
III. Sample calculation

IV. Results

V. Conclusion

I. CO_2- quantification method

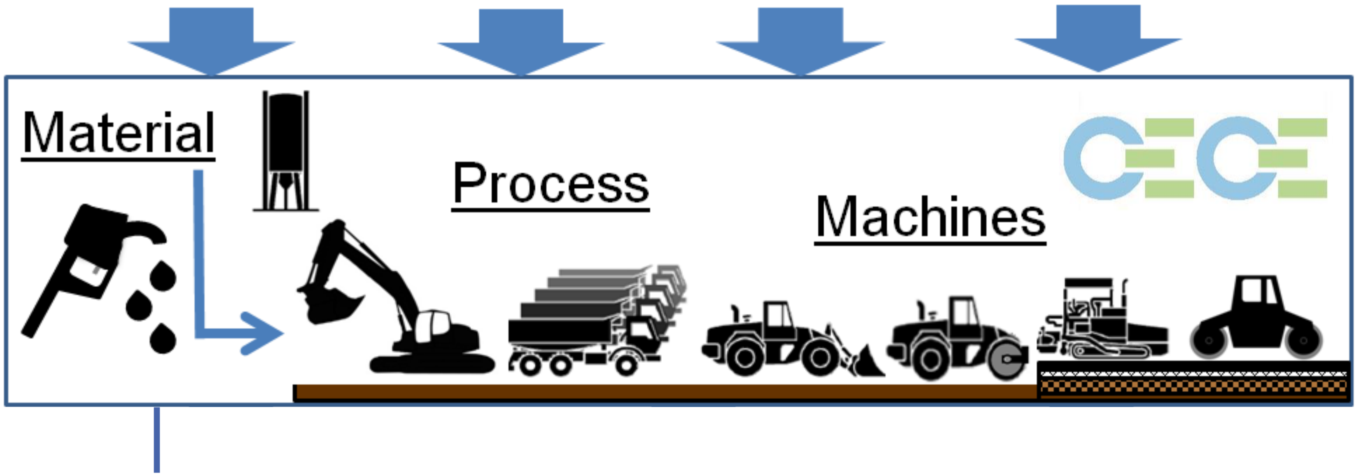
A. *Common method*



Picture source: Liebherr & Wirtgen & CEMA

I. CO_2- quantification method

A. *CECE - CO_2 quantification method*



System boundary

CO_2 from:

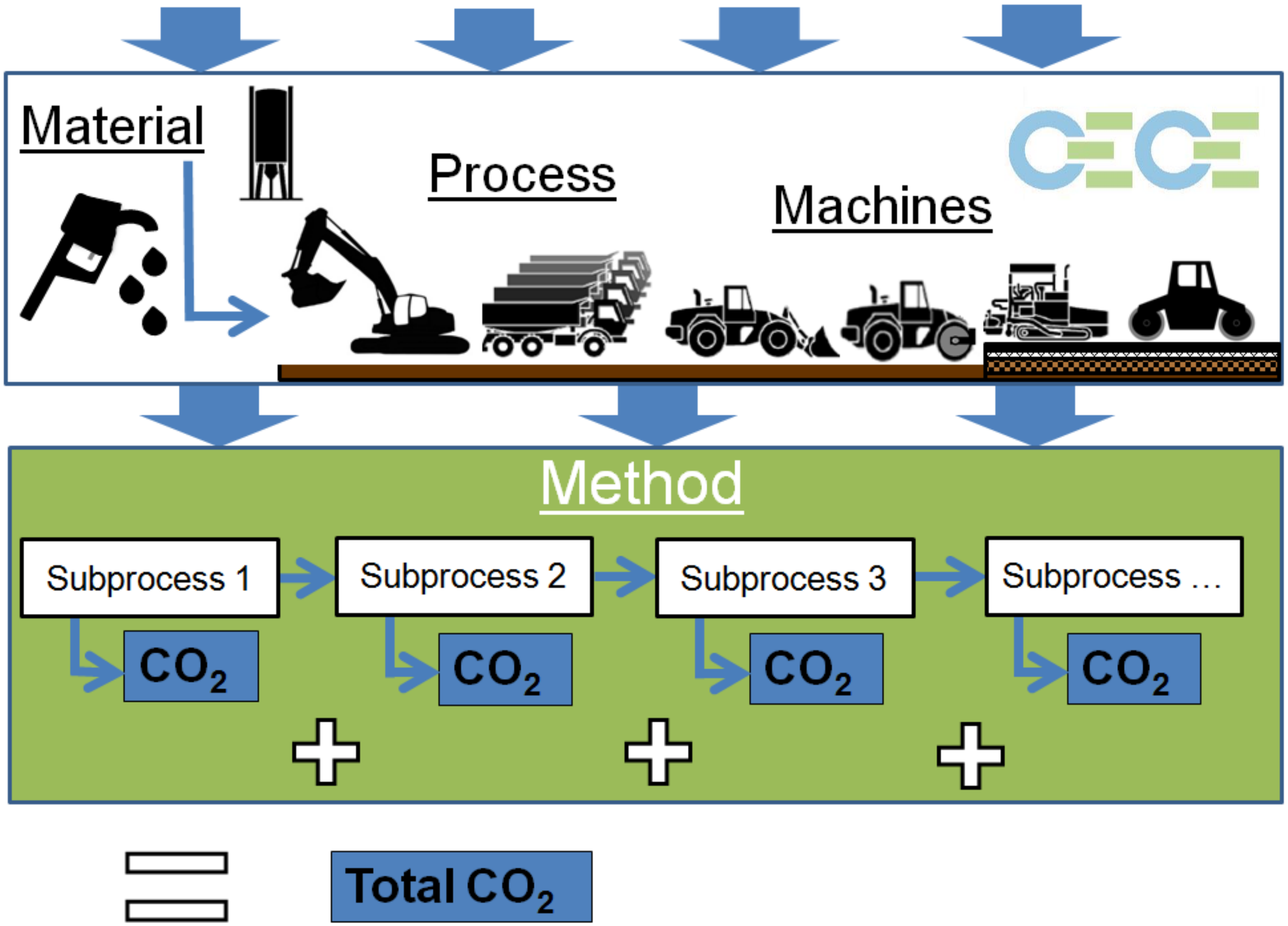
- Production of construction material
- Transport of material to and from the site
- Construction machines
- Production process of primary energy carrier (only from database)

Picture source: Liebherr & Wirtgen

I. II. III. IV. V.

I. CO_2- quantification method

A. *CECE - CO_2 quantification method*



Picture source: Liebherr & Wirtgen

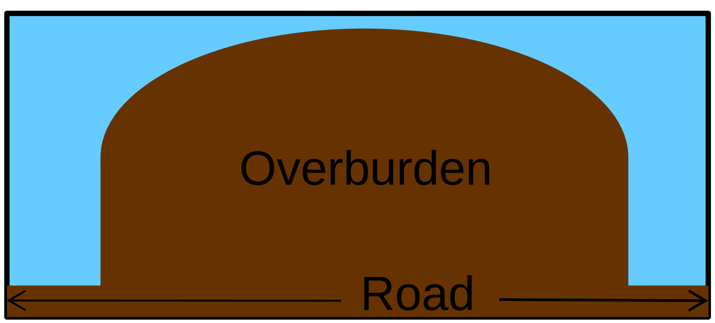
II. Application on a representative example

- <u>Proceeding:</u>
  - Application of the **method**
  - For a **road construction**
  - For the time scale **<u>past (1990-2009) – present (2010-2013)- future (2014-2020)</u>**

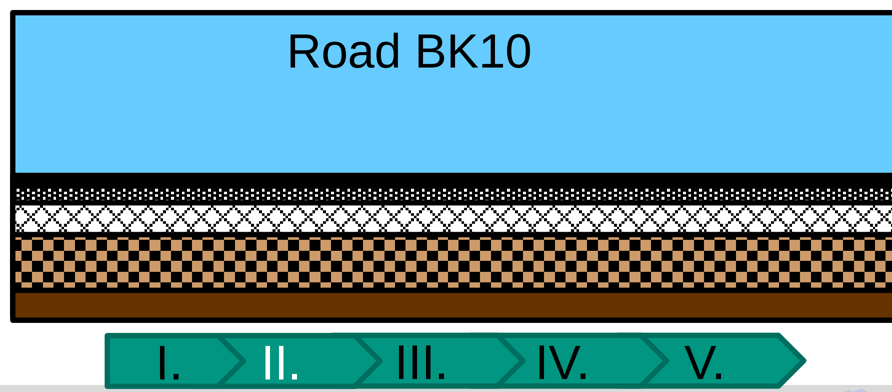
- <u>Representative example:</u>

Construction of a road BK10 in Karlsruhe

Earthmoving



Road building



I. CO_2- quantification method

- Background:

EU objective: reduction of CO_2 emissions in construction sites

- CECE Aim:

Show a market driven reduction of CO_2 emissions

- Procedure:

A. Similar approach as CEMA → convince EU

B. Develop a method to quantify the **attained** and **potential CO_2-reduction**

I. II. III. IV. V.

II. Procedure for the CO_2 quantification

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Determination of:

Earthmoving / Pavement

1. Work tasks
   (e.g. earth moved / road type)
2. Conditions / Requirements
   (e.g. soil class / thickness of the layers)
3. Construction site & working conditions
4. Material
5. Machines (on the construction site)
6. Number of machines
7. Distance driven by the machines

Machine efficiency

+

Process efficiency

+

Operation efficiency

+

Alternative energy sources

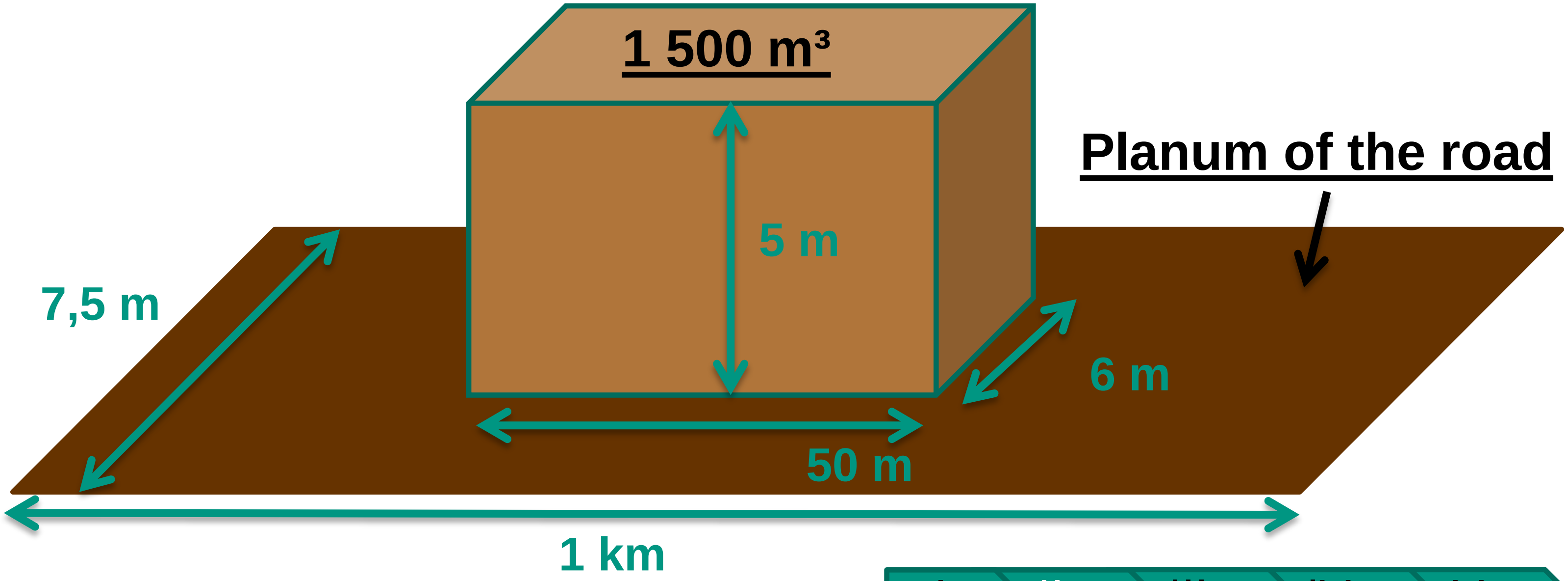
CO_2

I. II. III. IV. V.

II. Application on the representative example

1. Work tasks & 2. Conditions / Requirements

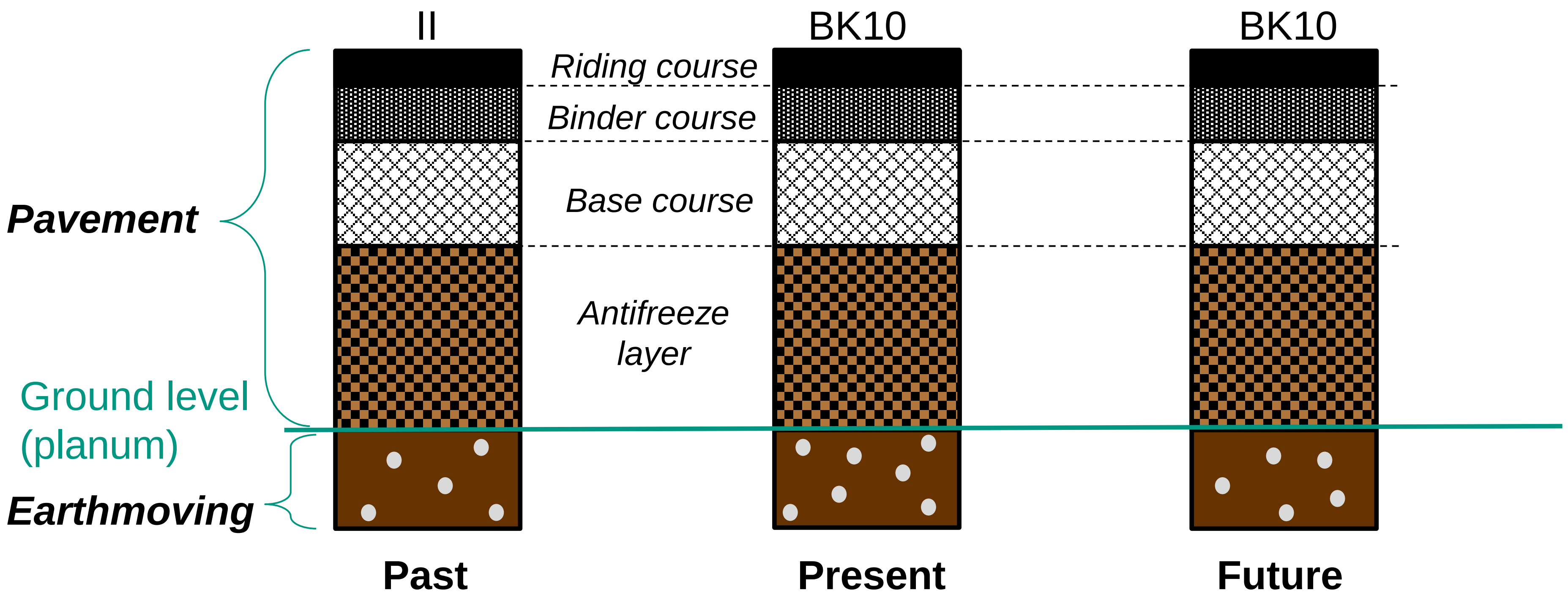
- <u>Adjustment of the representative example</u>
  - Soil: Brown earth & luvisol from wind & terrace sand (in Karlsruhe) (1+2)
    - ➡ No cohesive,
    - ➡ sand, gravel, silt, clay
    - ➡ **Soil class 3** (DIN 18300)



II. Procedure for the construction of a road

Karlsruher Institut für Technologie

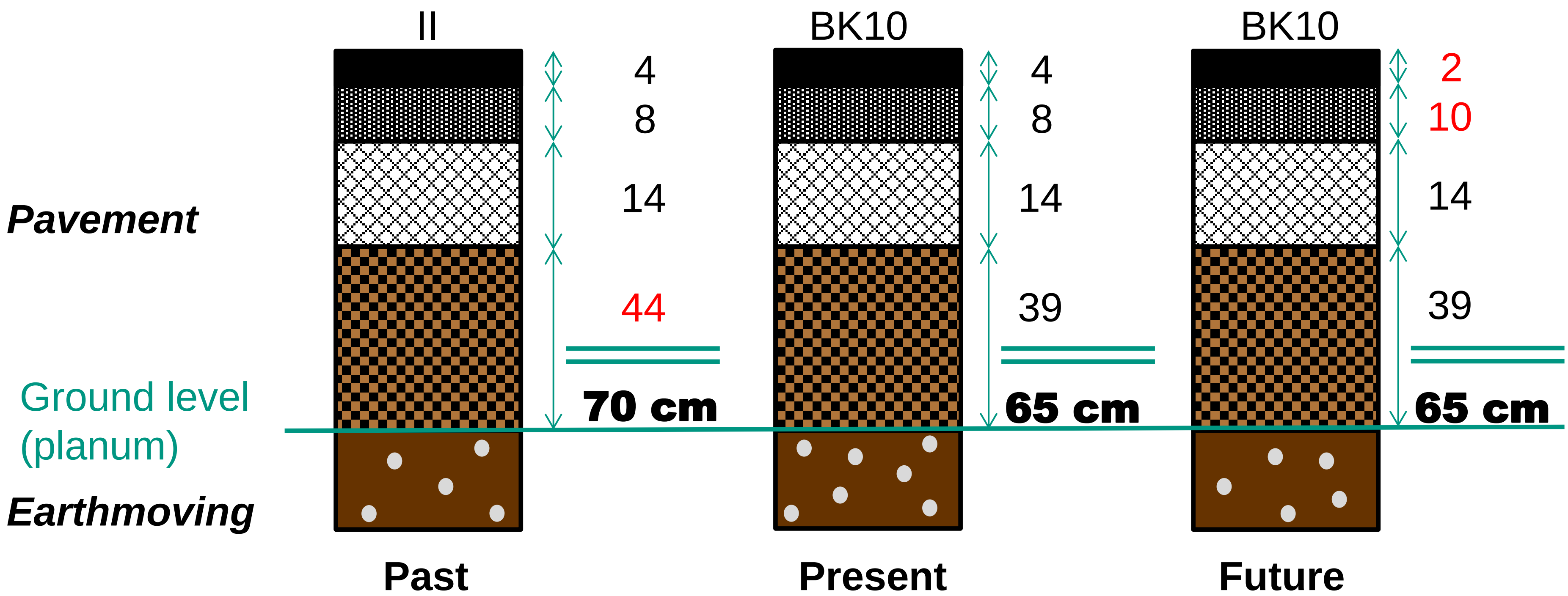
1. Determination of the road type



I. II. III. IV. V.

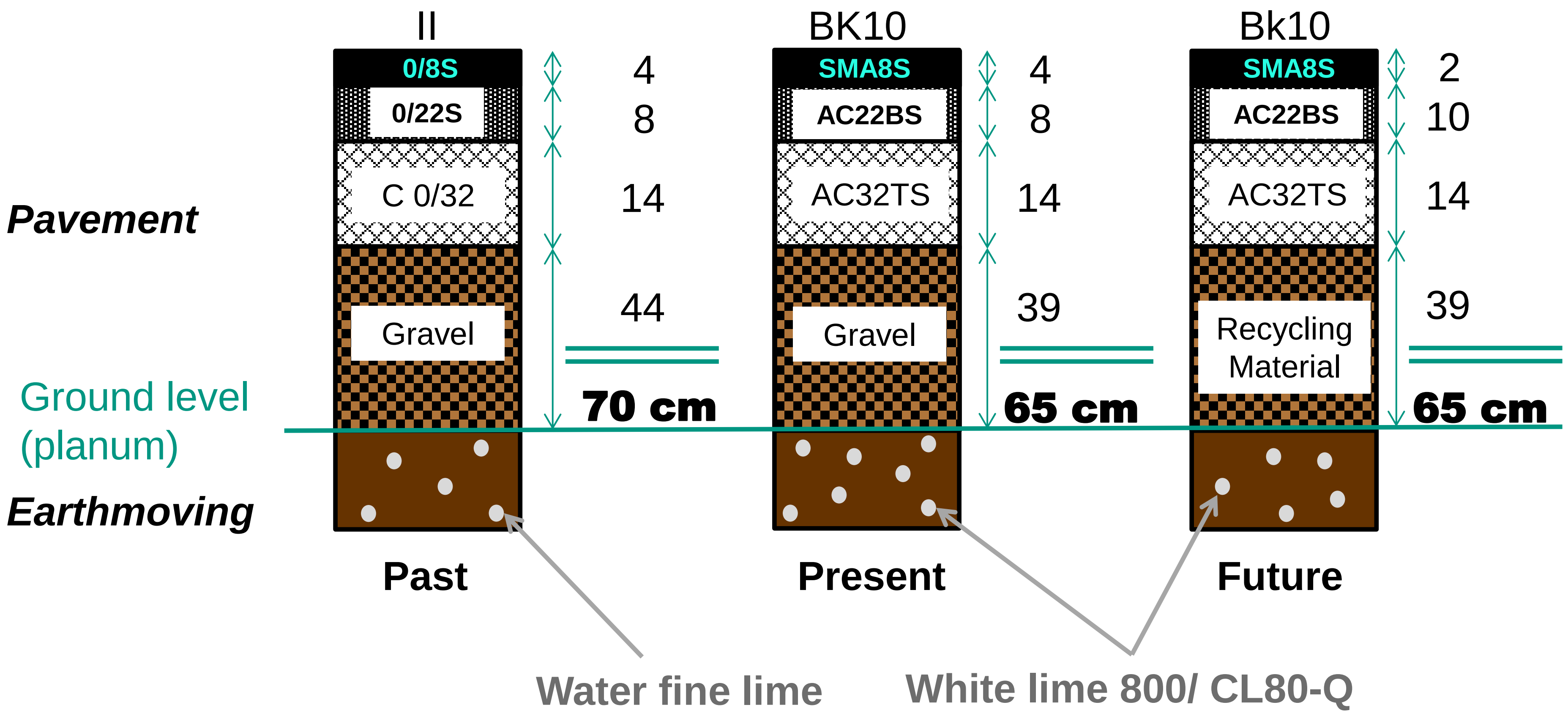
II. Procedure for the construction of a road

1. Determination of the road type & 2. Thicknesses of the layers



II. Procedure for the construction of a road

3. Material



I. II. III. IV. V.

II. Procedure for the construction of a road

4. Machines

- Hydraulic excavator (25-27t ; 112-140 kW)
- Truck (265 kW)
- Crawler dozer (120 kW)
- Grader (142 kW)
- Vibratory roller (10-11,5 t ; 74 kW for asphalt ; 119 kW for earth)
- Limestone tank truck (41t ; 405 kW)
- Soil stabilizer (315 kW)
- Padfoot compactor (11,5 t ; 115 kW)
- Spreader (300 kW)
- Paver (127 kW)
- Material feeder (160kW)

I. II. III. IV. V.

II. Procedure for the construction of a road

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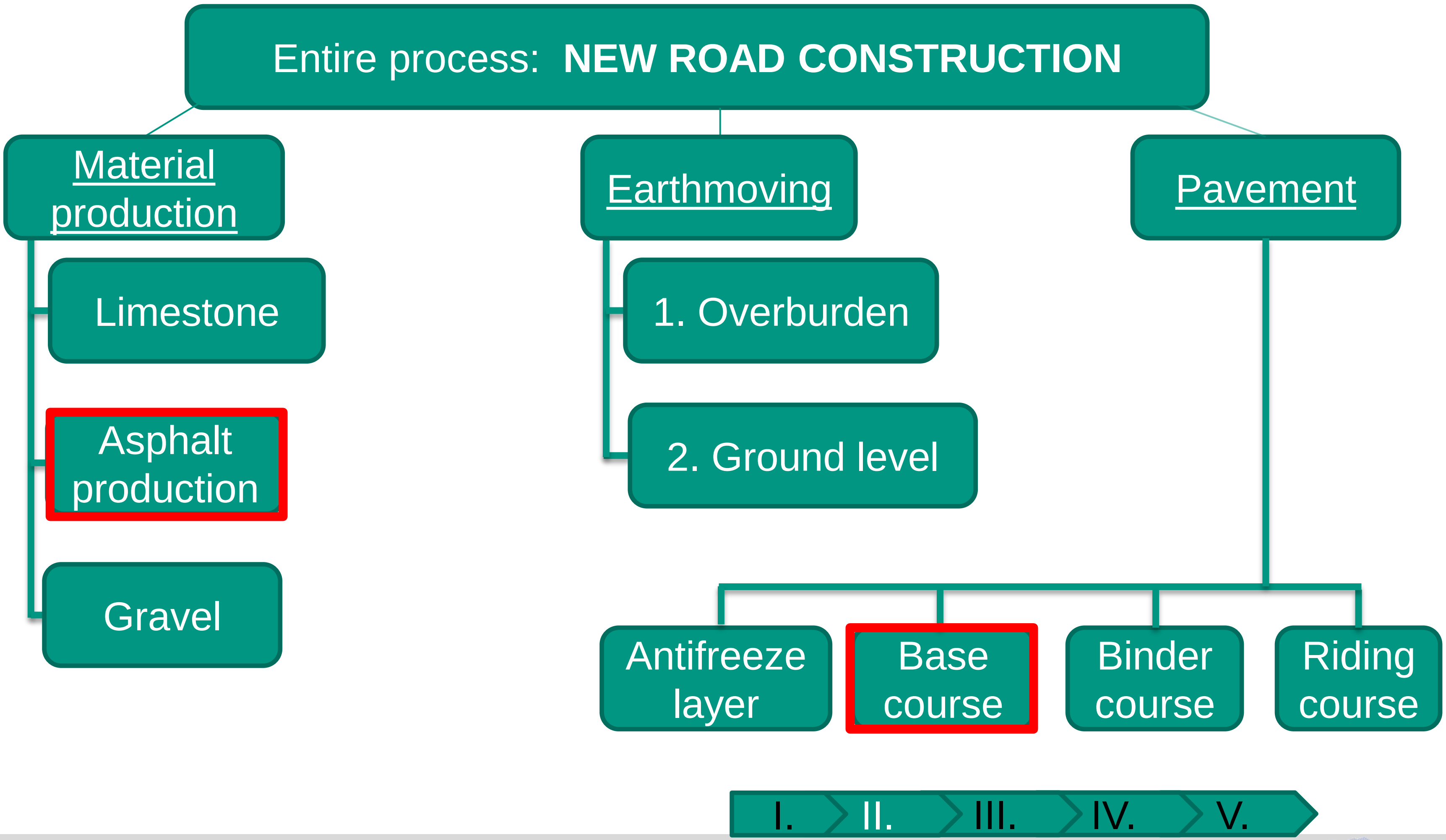
5. Process

- Entire process: **NEW ROAD CONSTRUCTION**
  - Material production
    - Limestone
    - Asphalt production
    - Gravel
  - Earthmoving
    - 1. Overburden
    - 2. Ground level
  - Pavement
    - Antifreeze layer
    - Base course
    - Binder course
    - Riding course

I. II. III. IV. V.

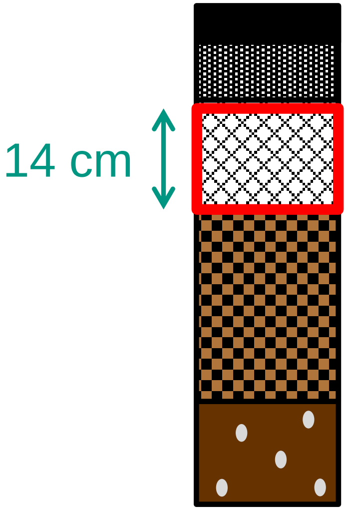
II. Procedure for the construction of a road

5. Process



III. Sample calculation: Asphalt production

General information AC32TS		
Asphalt production	46	kg CO2/t
Thickness	0,14	m
Total quantity	1050	m³
Density	2312	kg/m³ (4)
Total weight	2427	t



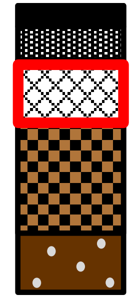
- Asphalt production:

$46\ kg\ CO_2/t \times 2427\ t = \mathbf{111{,}7\ t\ CO_2}$

III. Sample calculation: Base course

Pavement

Source: bauforum24.biz



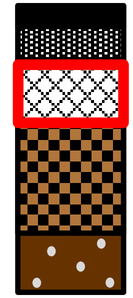
Source: AMMANN

Aim	2. Base course					
Process	**2.1 Pavement**					
Subprocesses	Transport	Unloading	Paving	Precompaction	Compaction	
Machines Type	**Rear-dump truck** 265 kW – 13m³		**Paver** 127 kW – 7,5m width		**Tandem roller static** 74kW 10t-11,5t	**Tandem roller dynamic** 74kW 10t-11,5t

Material
AC32TS

I. II. III. IV. V.

III. Sample calculation: Base course



Pavement

Source: bauforum24.biz

Source: AMMANN

Aim	2. Base course					
Process	**2.1 Pavement**					
Subprocesses	Transport	Unloading	Paving	Precompaction	Compaction	
Machines Type	**Rear-dump truck** 265 kW – 13m³		**Paver** 127 kW – 7,5m width		**Tandem roller static** 74kW 10t-11,5t	**Tandem roller dynamic** 74kW 10t-11,5t

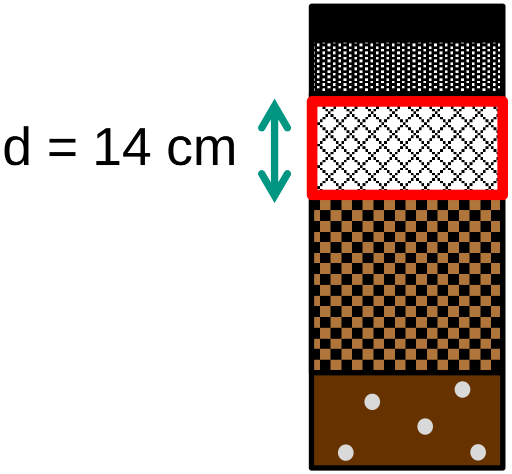
Material
AC32TS

I. II. III. IV. V.

III. Sample calculation: Base course, paver

- **Asphalt quantity:** 1050 m³

- **Paver data :**
  - Working velocity: v_{paver} = 480 m/h
  - Working width: b‘ = 7,5 m
  - Engine performance: P_{max} = 127 kW
  - Consumption: b = 175 g/kWh



Paver data source (3) + Wirtgen group

I. II. III. IV. V.

III. CO_2 quantification basics for mobile machines

Karlsruher Institut für Technologie

- CO_2 quantification emitted by mobile machines:

$$\boxed{\begin{array}{l} CO_2 = B \times (2{,}6 + 0{,}4) \\ CO_2e = B \times (2{,}6 + 0{,}6) \end{array}}$$

Emissions for diesel production (6+7)*:*
0,4 kg CO_2/l_{diesel} or 0,6 kg CO_2e/l_{diesel}

CO_2 emissions for diesel combustion (CO_2~CO_2e) (5)*:*
2,63 kg CO_2/l_{diesel}

- Total consumption for the subprocess : $B = P \times b \times t_i$

b = specific fuel consumption

- Performance: $P = 0{,}7 \times P_{max}$

P_{max} = maximal engine power

- Working time (3): $t_i = \dfrac{\text{Volume of material}}{Q_E}$

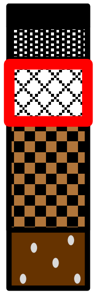
- Effective capacity (3): $Q_E = Q_B \times 0{,}75 \times 0{,}9$

Utilisation factor : 0,75

Factor for unforeseeable difficulties: 0,9

- Firm capacity (3): $Q_B = \dfrac{\text{nominal machine volume}}{\text{time}}$

III. Sample calculation: paver



- CO_2 quantification emitted by mobile machines:

$$\boxed{\begin{array}{l} CO_2 = B \times (2{,}6 + 0{,}4) = 0{,}177\ \mathrm{t} \\ CO_2e = B \times (2{,}6 + 0{,}6) = 0{,}184\ \mathrm{t} \end{array}}$$

- Total consumption for the subprocess: $B = P \times b \times t_i = 57{,}9\ l$

- Performance: $P = 0{,}7 \times P_{max} = 88{,}9\ kW$

- Working time: $t_i = \dfrac{\text{Volume of material}}{Q_E} = 3{,}1\ h$

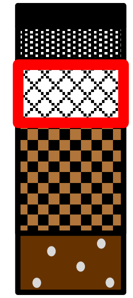
- Effective capacity: $Q_E = Q_B \times 0{,}75 \times 0{,}9 = 340\ m^3/h$

- Firm capacity: $Q_B = b' \times v_{paver} \times d = 504\ \mathrm{m^3/h}$

III. Sample calculation: Base course

Source: bauforum24.biz

Pavement



Source: AMMANN

Aim	2. Base course					
Process	**2.1 Pavement**					
Subprocesses	Transport	Unloading	Paving	Precompaction	Compaction	
Machines Type	**Rear-dump truck** 265 kW – 13m³ **8,99 t CO_2**		**Paver** 127 kW – 7,5m width **0,177 t CO_2**		**Tandem roller static** 74kW 10t-11,5t **0,093 t CO_2**	**Tandem roller dynamic** 74kW 10t-11,5t **0,291 t CO_2**

Material
AC32TS

111,7 t CO_2

Total: 121,3 t CO_2

I. II. III. IV. V.

IV. Results

IV. Results: differences between
earthmoving - pavement - material

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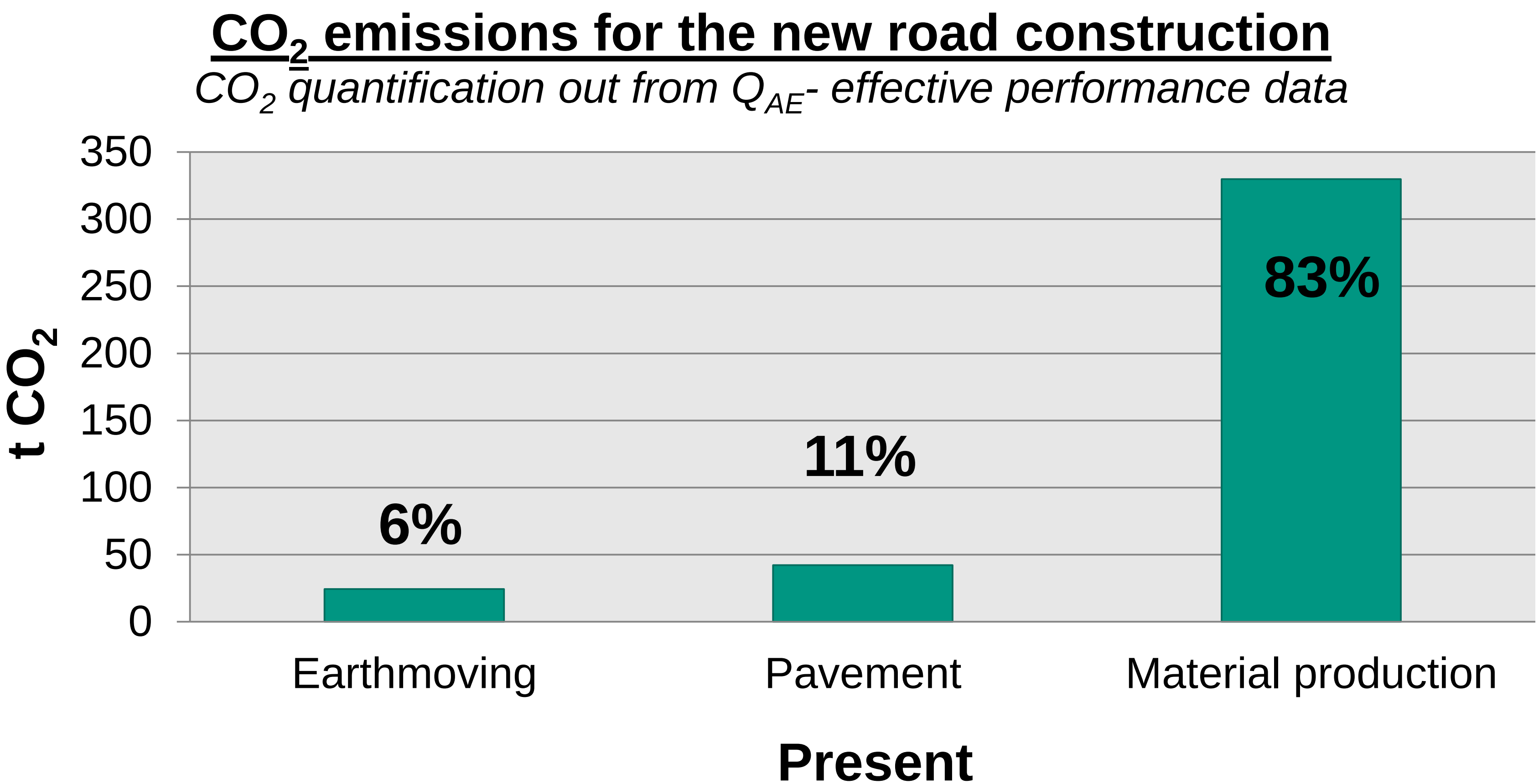
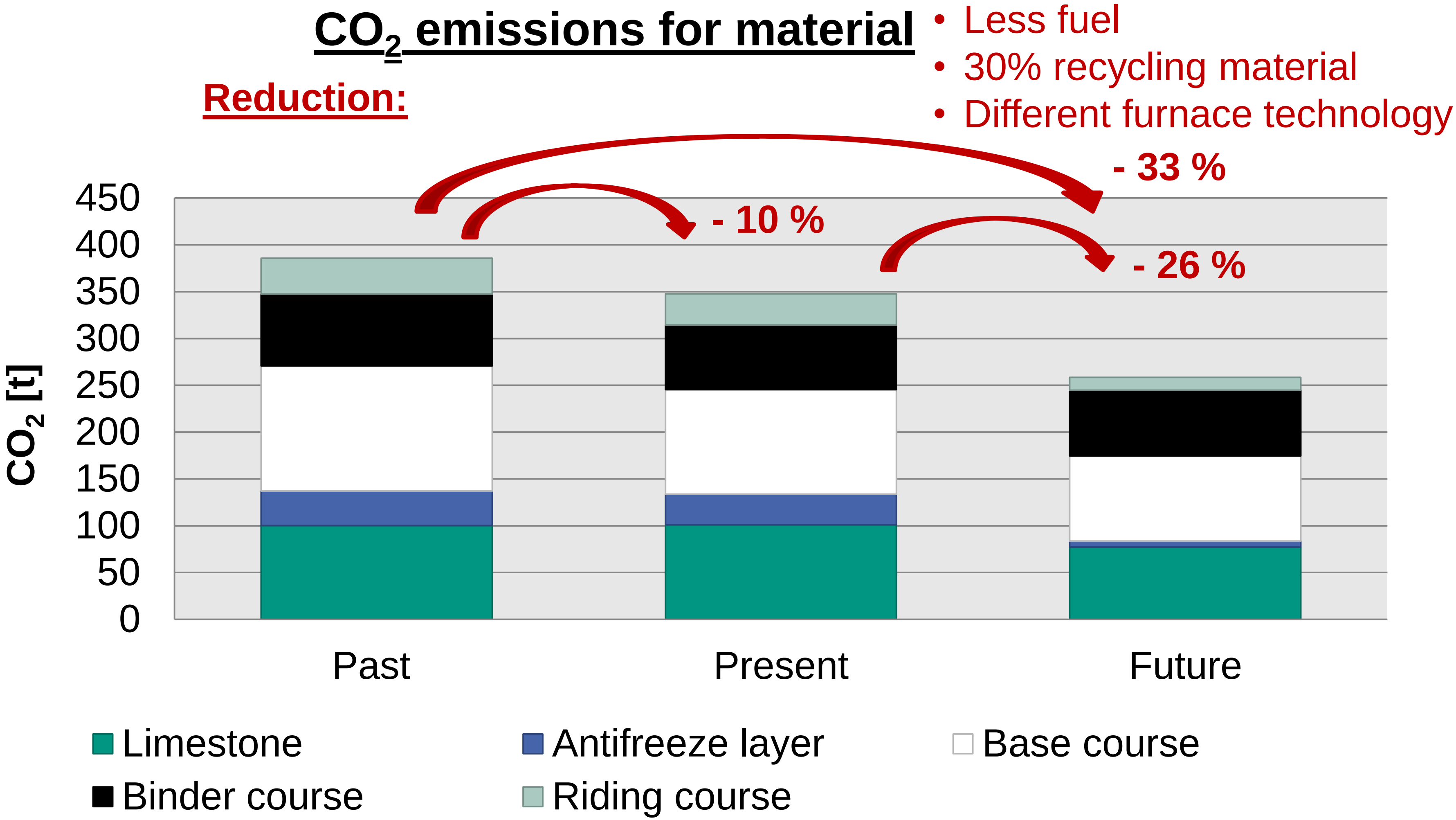


I. II. III. IV. V.

Dipl.-Ing. Isabelle Ays / Prof. Dr.-Ing. Marcus Geimer

Institut für Fahrzeugsystemtechnik (FAST)
Lehrstuhl für Mobile Arbeitsmaschinen (Mobima)

IV. Results: Material production



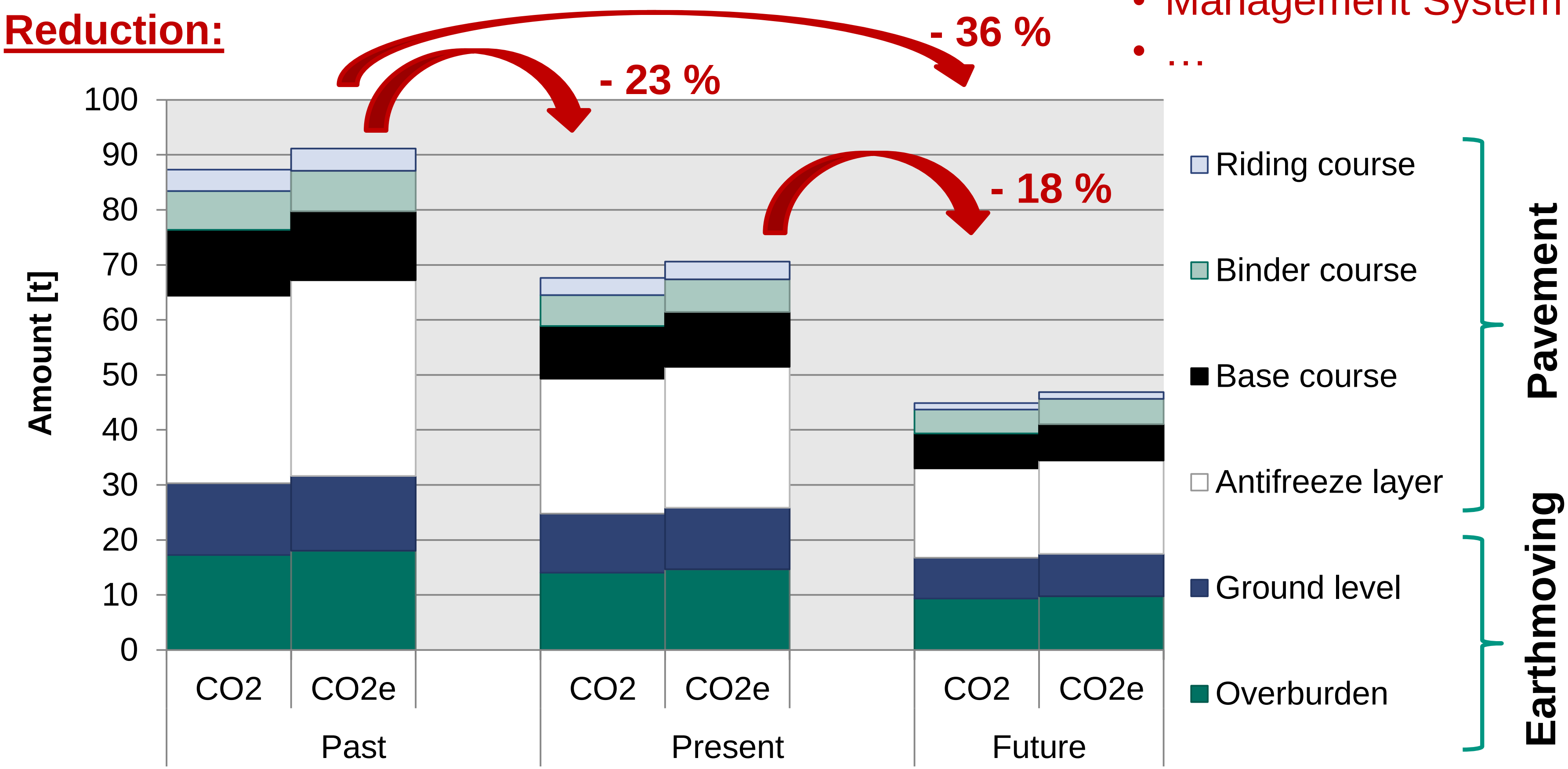
I. II. III. IV. V.

IV. Results: job-site processes

Machine efficiency: lower fuel consumption

- Common rail injection
- Ecomode
- Management System
- …

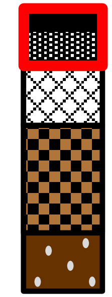
Reduction:



I. II. III. IV. V.

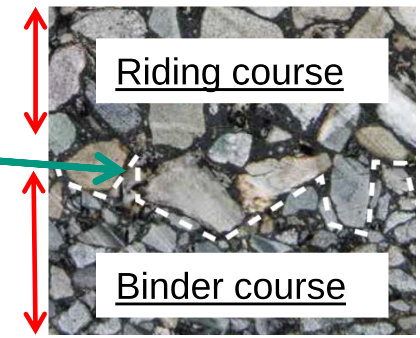
IV. Results: Influences of the 4 pillar approach on a simulation example

IV. Results: Simulation example



- <u>Operation efficiency:</u> 10% better site/working conditions
  → Utilisation factor: 0,75 ⟶ 0,85
- <u>Process efficiency:</u>
  1. Same truck capacity with 10 % less trucks: e.g. 33 → 30 trucks
  2. **“Hot on Hot”**
     - High interdigitation
     - Different material ratio
     - Different machines:
       “+ 1 paver ”
       + 1 material feeder
       - 2 rollers

High interdigitation
(=dt. Verzahnung)



Source: Vögele (Wirtgen Group)

✓ <u>Machine efficiency:</u> lower fuel consumption

Source: Vögele (Wirtgen Group)

I. II. III. IV. V.

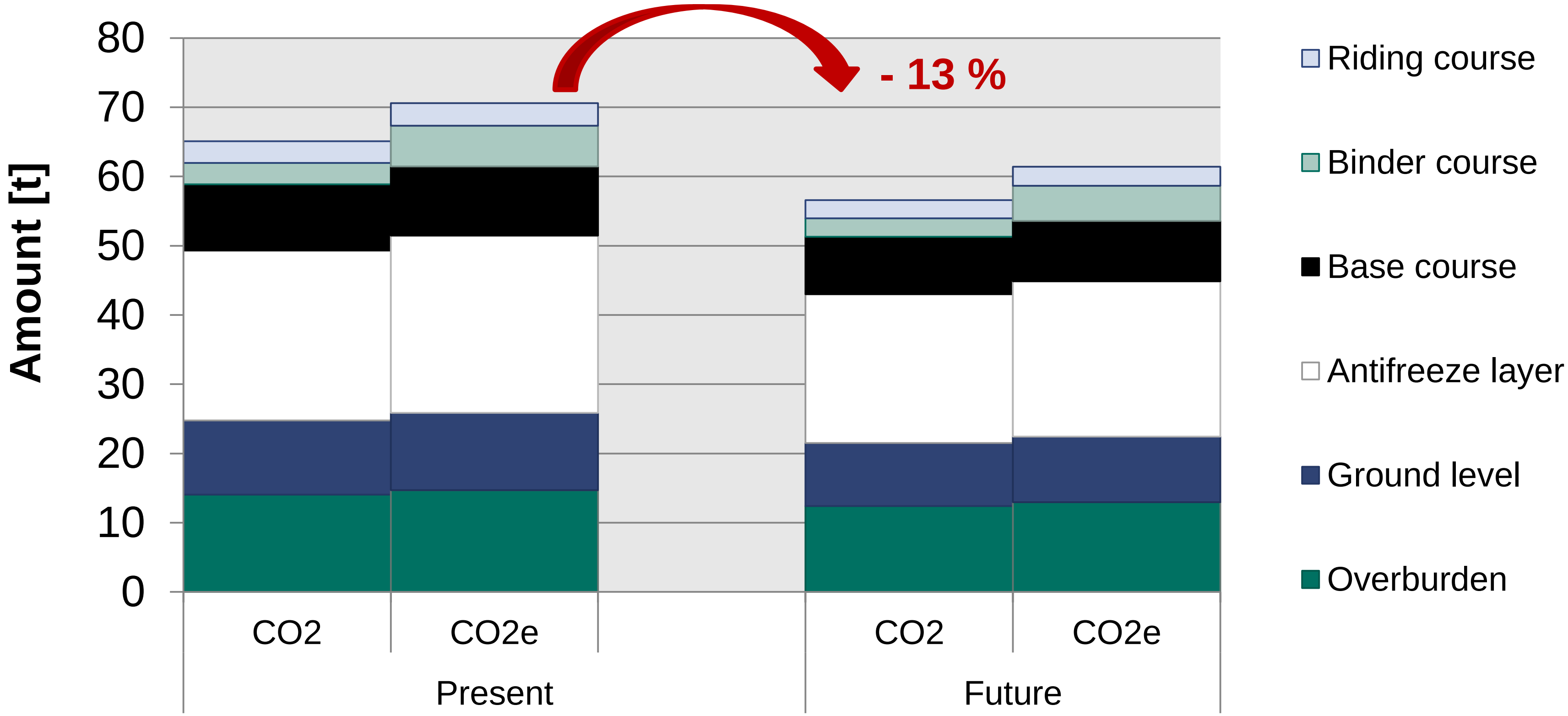
IV. Results: Influences of the 4 pillar approach

- Only operation efficiency

Operation efficiency

Utilisation factor: 0,75 → 0,85

- Tyre pressure control
- Correct settings
- Driving cycle amelioration
- …



I. II. III. IV. V.

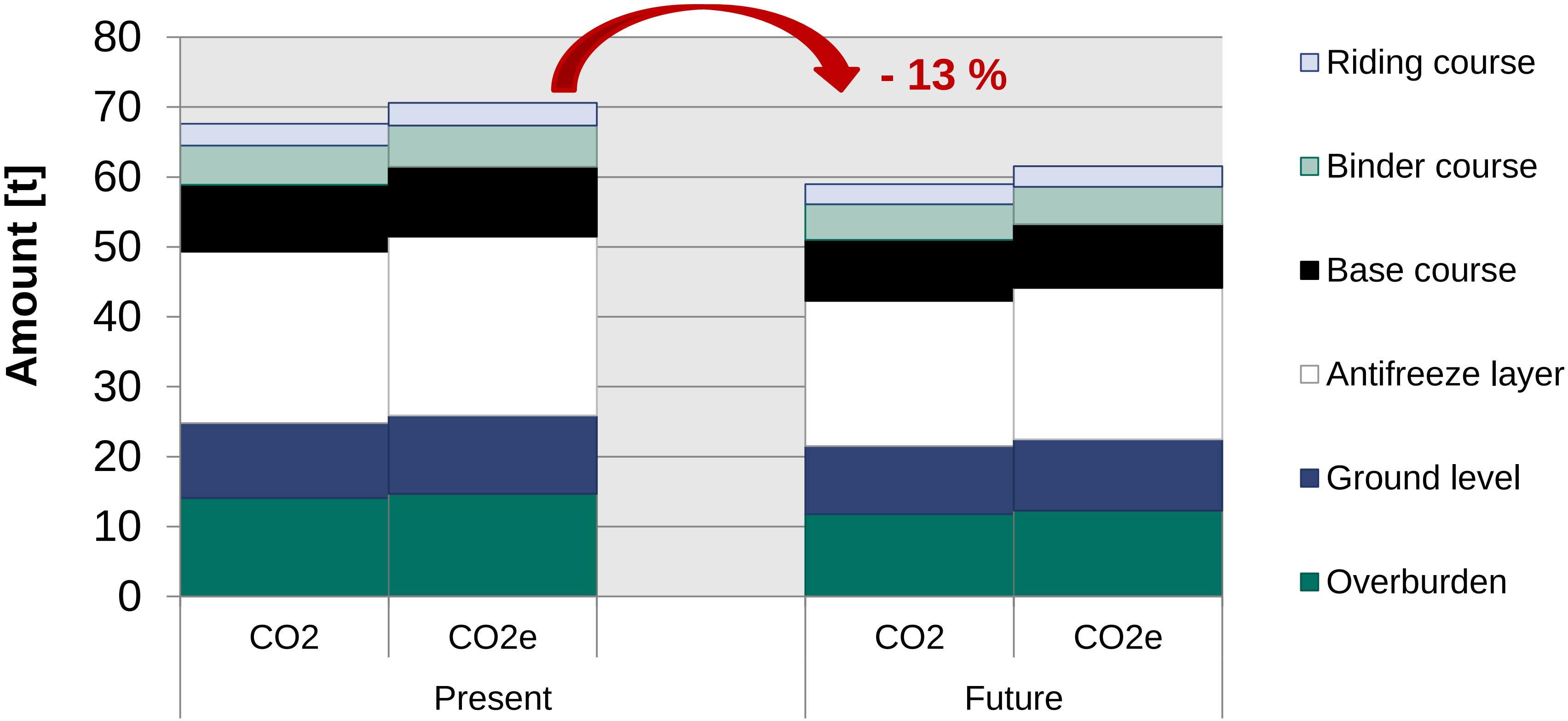
IV. Results: Influences of the 4 pillar approach

- Only process efficiency

Process efficiency:

10 % less trucks: e.g. 33 → 30 trucks

- Lower fuel consumption
- Bigger Volume
- …



I. II. III. IV. V.

IV. Results: Influences of the 4 pillar approach

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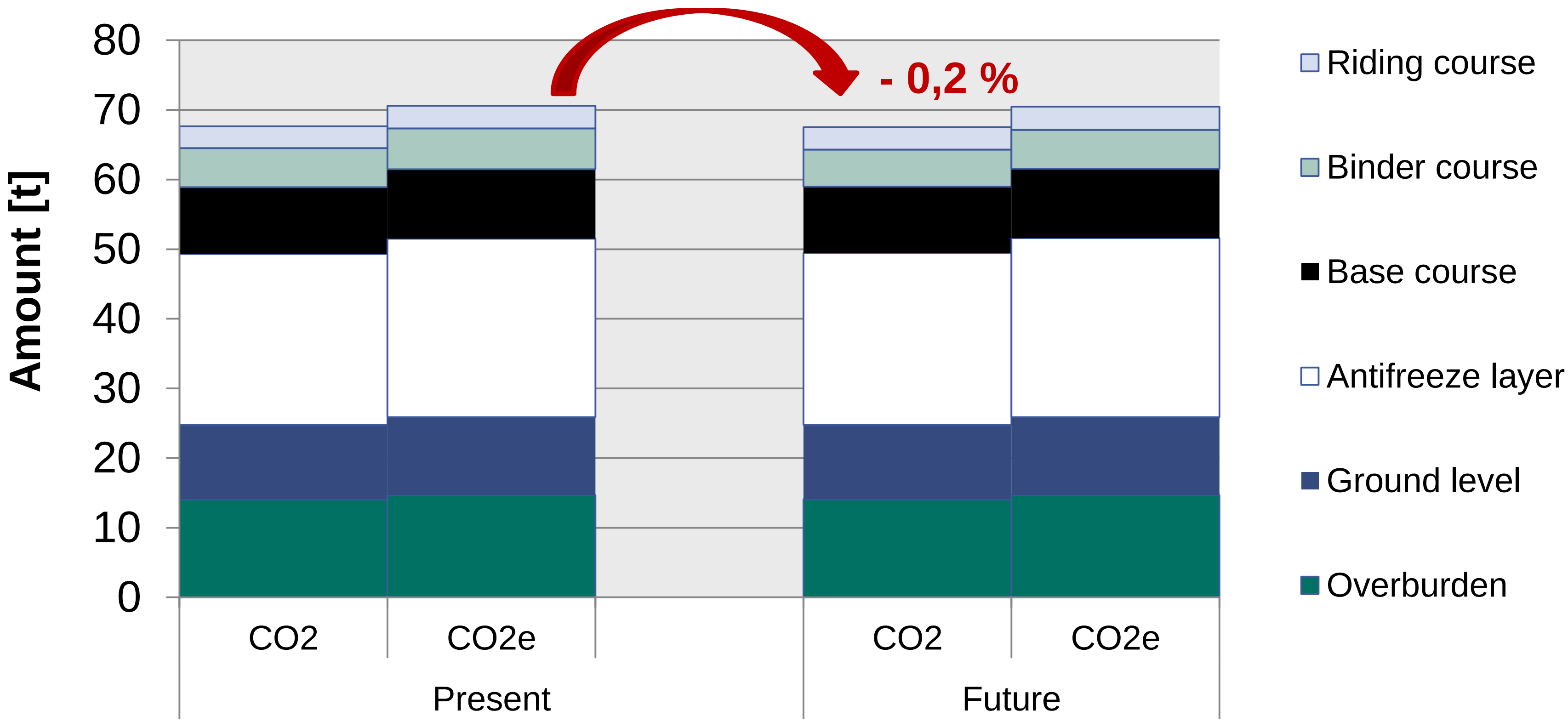
- Only process efficiency (not material)

Process efficiency: only "Hot on Hot"

- + 1 material feeder
- - 2 rollers



I. II. III. IV. V.

V. Conclusion

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- Summary
  - Elaboration of the method
  - Application on a new road construction of type BK10
  - Identification of the **material** & **processes** & **machines**
  - CO_2 quantification & CO_2 attained and potential reduction

Machine efficiency	**Attained CO_2 reduction 1990-2013**	**Potential CO_2 reduction 1990-2020**
Job-site processes	**23 %**	**36 %**
Material	**10 %**	**26 %**

I. II. III. IV. V.

List of references

(1) Solum, Büro für Boden + Geologie; *Landschaften und Böden im Regierungsbezirk Karlsruhe;* Regierungspräsidium Karlsruhe; Stuttgart; p.14

(2) X. Schuler; *Leitlinie: Zur Festlegung der Überdeckungen von Trinkwasserleitungen in Baden-Württemberg*; INTECS Engineering Services, EnBW Regional AG & Ministerium für Umwelt und Verkehr Baden Württemberg; Stuttgart; p.13

(3) Manfred Hoffmann, Thomas Krause et al.; *Zahlentafeln für den Baubetrieb*; 8. Edition; 2011; Vieweg + Teubner Verlag; ISBN 978-3-8348-0934-6

(4) Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV), Arbeitsgruppe Asphaltbauweisen*; ZTV Asphalt-StB 07/13*; Edition 2007/ Version 2013

(5) Bayerisches Landesamt für Umwelt (LfU); *Leitfaden für effiziente Energienutzung in Industrie und Gewerbe*; 2. Edition; November 2009; p.40

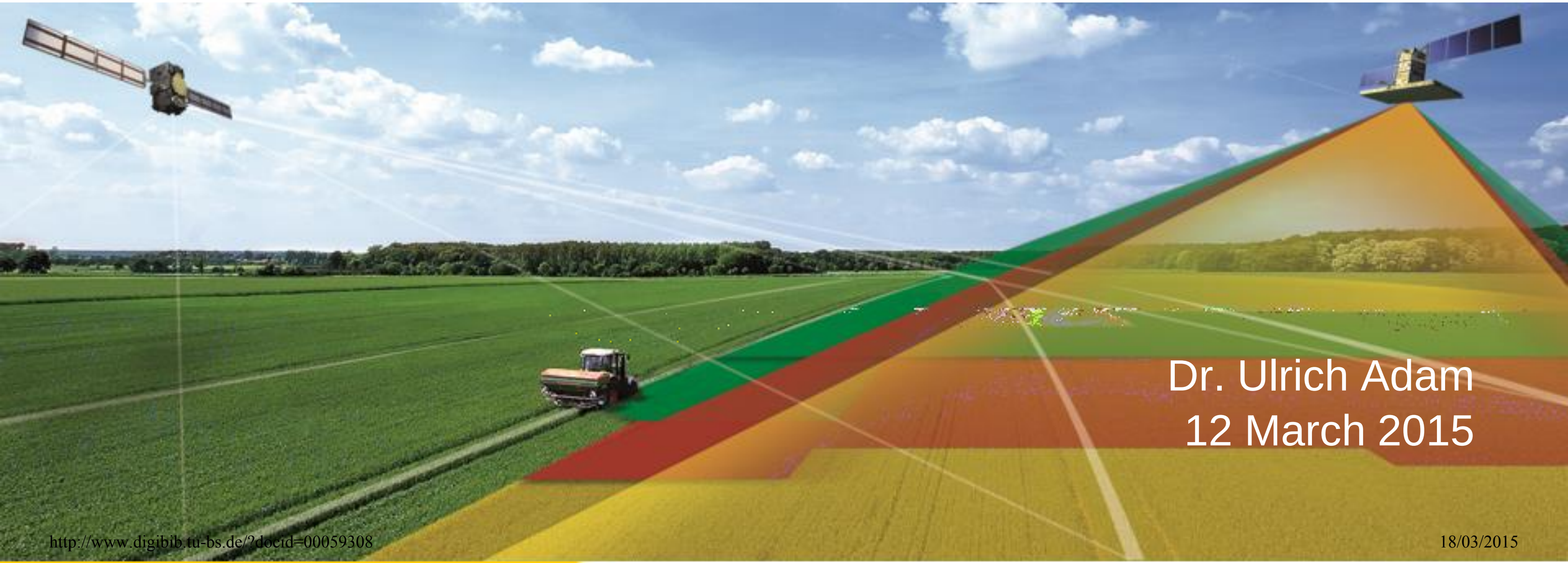
(6) R. Edwards, J. Larivé et al.; WELL-TO-TANK Appendix 1 – Version 4a; European Commission, Joint Research Centre, Institute for energy and Transport

(7) R. Edwards, J. Larivé et al.; WELL-TO-TANK Appendix 2 – Version 4a; European Commission, Joint Research Centre, Institute for energy and transport

CEMA

EUROPEAN AGRICULTURAL MACHINERY

CO2: We need smart regulation for mobile machines



Dr. Ulrich Adam

12 March 2015

Roadmap

1. General theory: what is smart regulation?
2. General practice: can EU regulatory approaches be considered smart?
3. Specific theory: what do we want the regulators to do on CO2 mitigation in agriculture?
4. Specific practice: what are regulators doing on CO2 mitigation in agriculture?
5. Our task: what can we do to get it right?

1. What is smart regulation?

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What is smart regulation? Traditional industry view/EU 2020 Strategy

- **Reduce** administrative burden & net cost of EU regulation for businesses

- **Assess** thoroughly the impact of legislation, ideally BEFORE legislating and regularly review existing legislation

- **Repeal** and/or simplify existing legislation, don't regulate unless absolutely necessary

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Smart Regulation 2.0: behavioural science dimension/‘nudging’

- Include behavioural insights in the design of regulatory proposals

- Awareness “that regulation cannot work effectively or efficiently if regulators do not consider how people respond” (A. Alemanno)

- Design policies that better reflect how people really behave, not how they are assumed to behave.

2. General practice: can the typical EU regulatory approach be considered smart?

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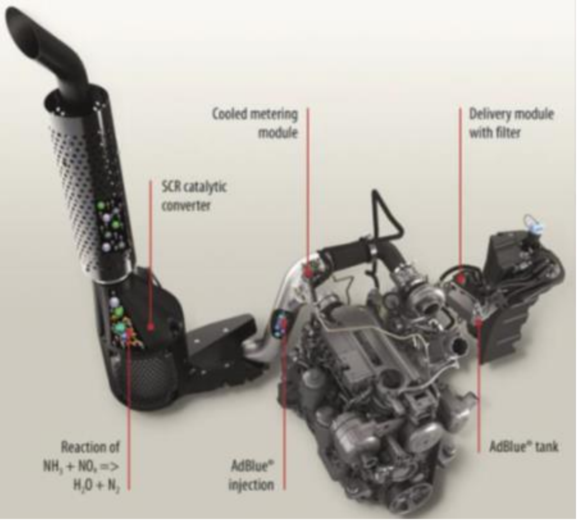
Diesel engine emissions – not so smart regulation?

- **Impact on industry**
  - Additional cost burden
  - Impact thoroughly assessed? Might other approaches not have delivered better results (roads not taken)?
  - Law of diminishing returns: long line of EU regulation…what's next?



- **Behavioural science dimension**
  - Where is the incentive for users? How do farmers respond (e.g. chip-tuning)???
  - GHGH mitigation options in farming only accepted *'if they result in positive income effects*'! (EU JRC report, p.5)

A modern fairy tale from Brussels – 1

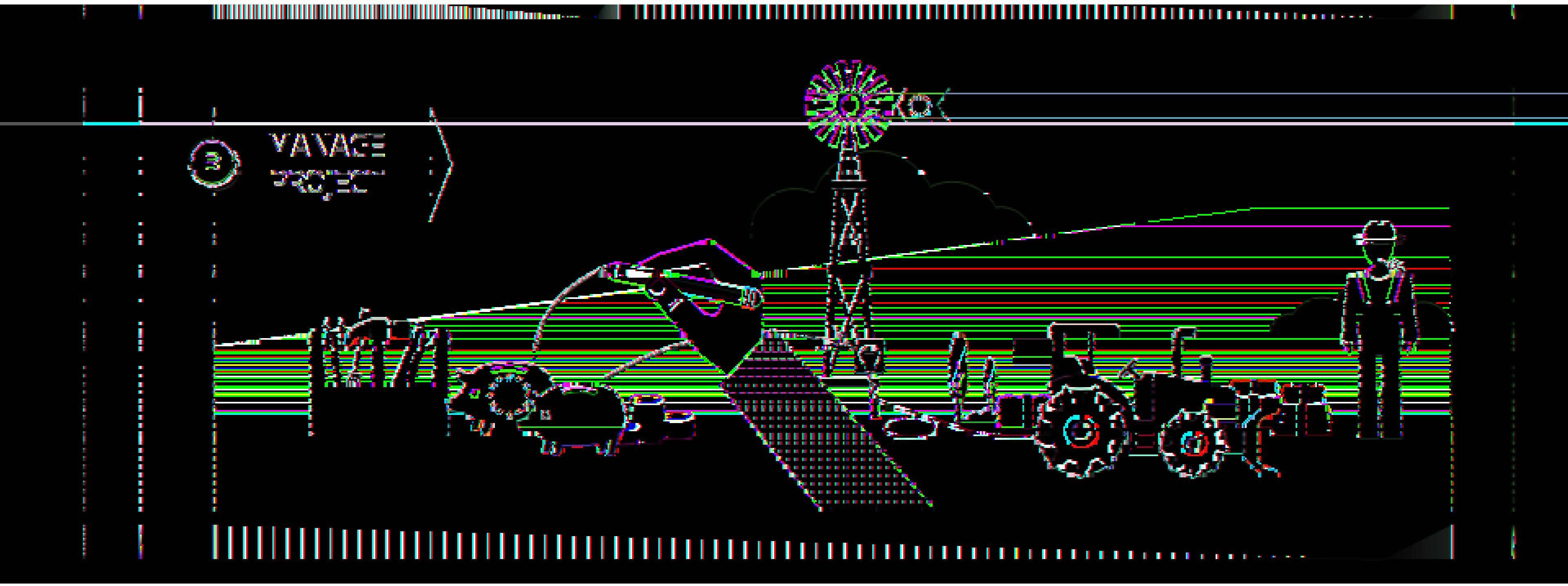
Once upon a time, there was a farmer who wanted to replace diesel engine emissions with clean wind energy….

A modern fairy tale from Brussels – 2

So he took up his own cash and applied for EU funding…

A modern fairy tale from Brussels – 3

…and solved the problem! Tractors now run on clean electric wind energy!



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The threat of regulator's naïveté: *'I have seen the future and it works'*

- **Dramatically overestimating**
  - user motivation/pull effect on demand
  - investment capacity of user
  - Regulatory push power to drive change
- **Grossly underestimating**
  - required R&D investment (of industry)
  - real change actors (in this case, industry)
  - Multiple practical problems along the way…
- **Reverse logic at its very best! Great theory, BUT…**
  - No real pull demand from the user
  - Difficult to create push effects without cost drawbacks on industry
  - Solution? Fantasizing about a strong [sic!] push [sic!] effect from the user???

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A fresh start for smart regulation?

"I want a European Union that is bigger and more ambitious on big things, and smaller and more modest on small things."

BUT:

- Will EU regulators really be ambitious/courageous enough to make strategic trade-offs?
- OR simply continue on a 'one-size-fits-all' and 'every-little-bit-counts' approach?
- Is the EU Commission's scattered internal organisation fit-for-purpose for an integrated, comprehensive task, such as smart, comprehensive CO2 reduction measures?

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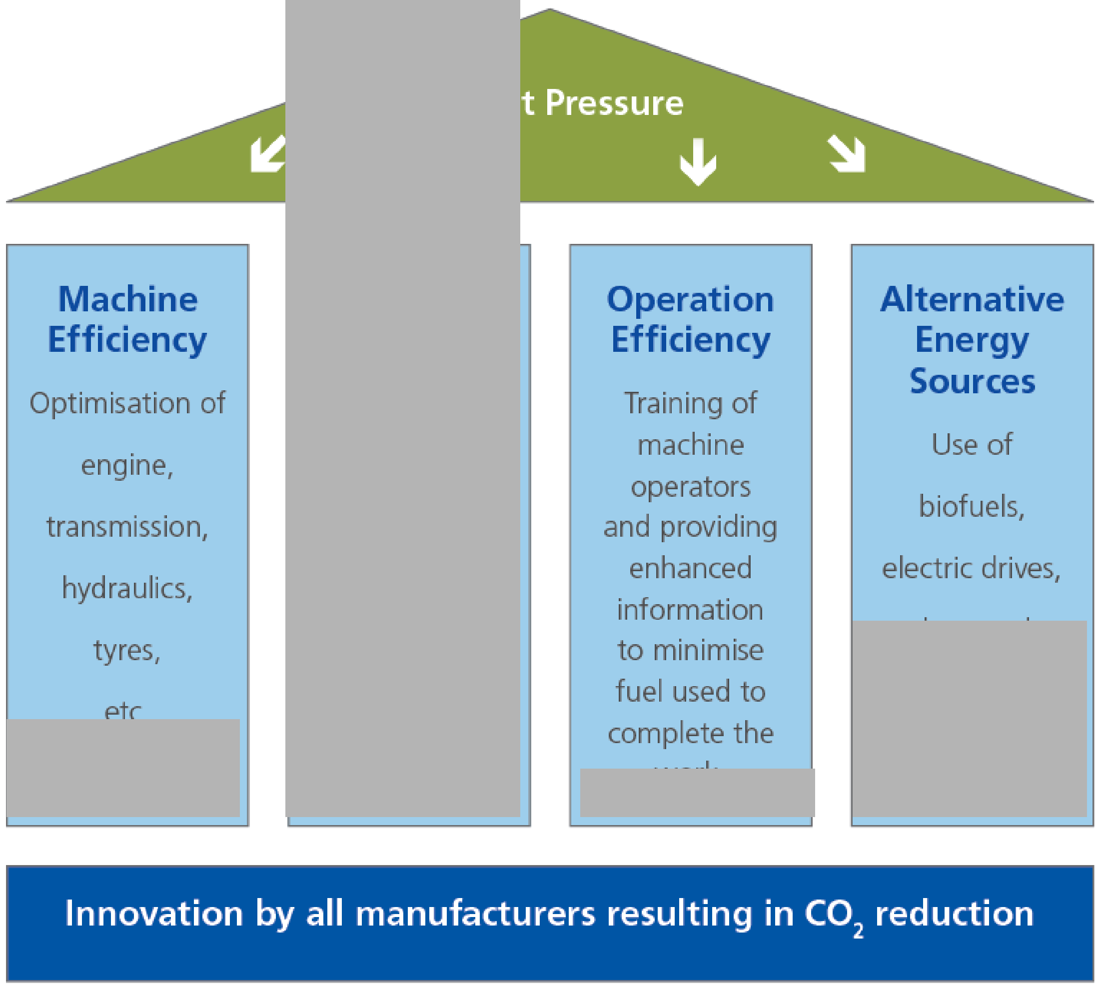
3. Specific theory: what do we want the regulators to do on CO_2?

Which of the Pillars offers the biggest CO2 saving potential?



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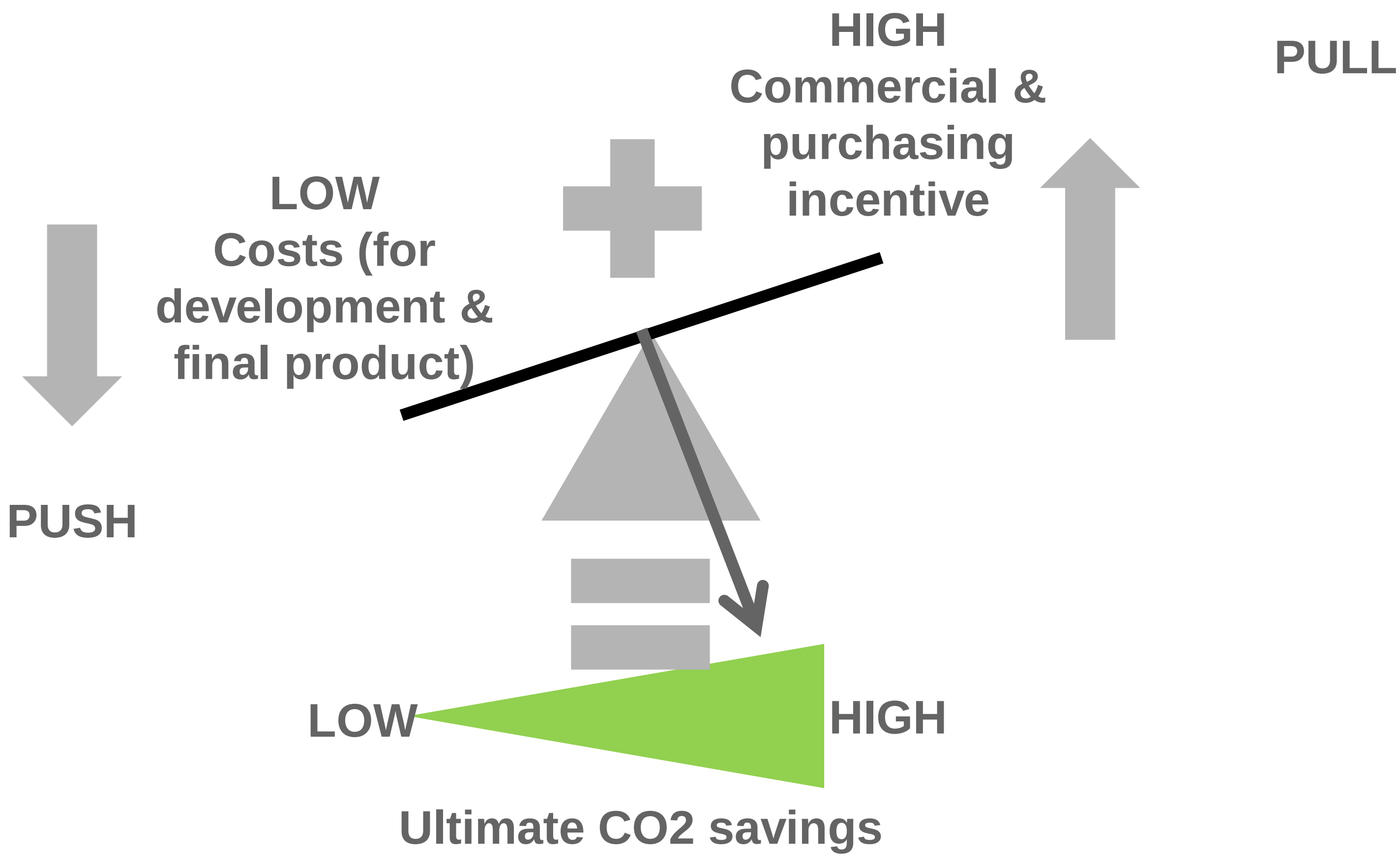
Regulatory best case



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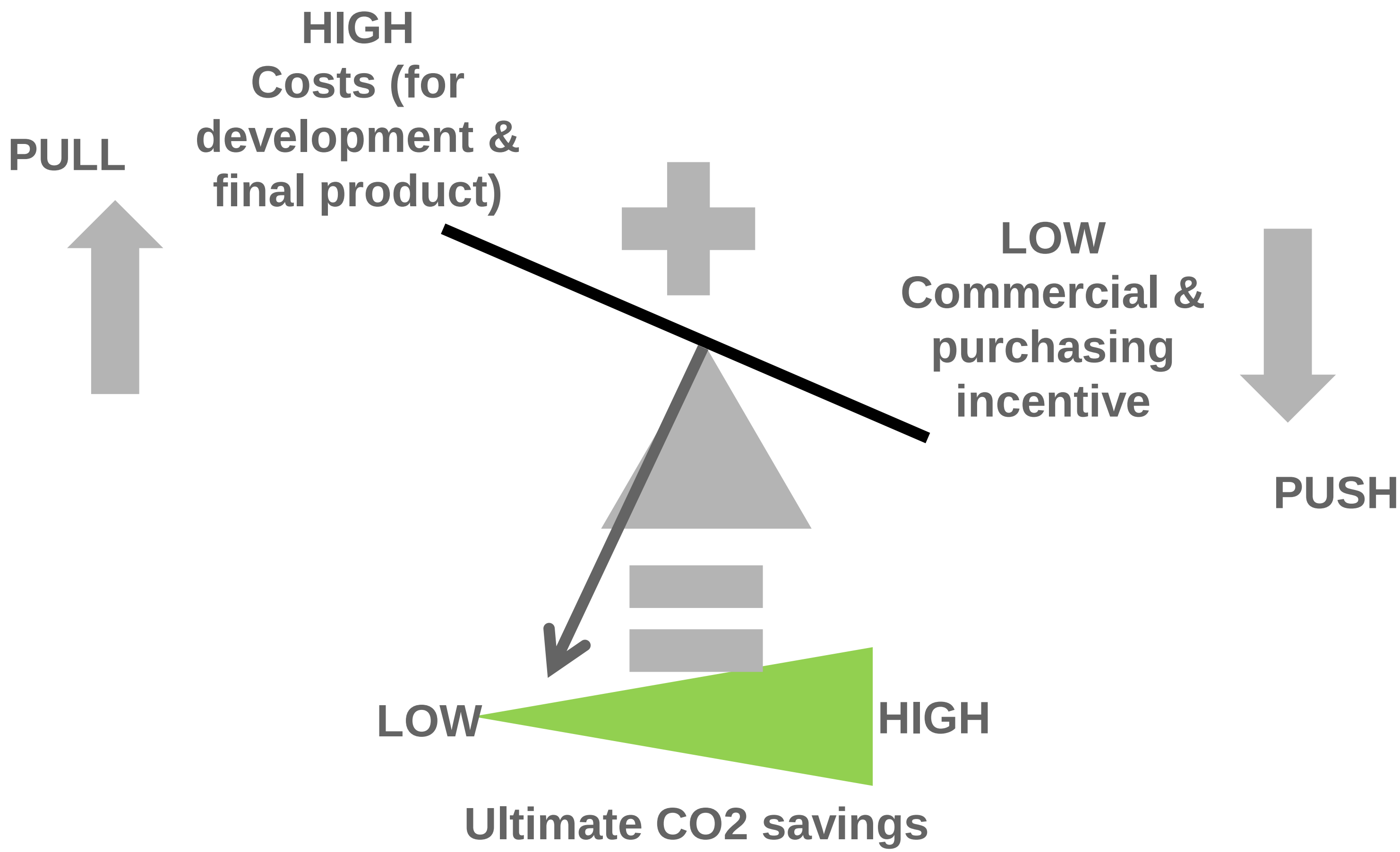
Regulatory worst case



Regulatory options – what is to be done?

- Define regulatory scope (small vs. comprehensive)
- Define regulatory measures (soft vs. hard)
- 3 scenarios

Regulatory options for agriculture – small scope, soft measures (light touch, no pain)

- **Soft pull from users:**
  - Ag machinery: top investment priority of EU farmers is new equipment…
  - …so why not think of incentive schemes to support investment in new machines and drive up replacement rates (high reduction potential)
  - Regulatory tools: tax brakes (national level) CAP payments (EU)
- **Soft push on producers:**
  - Increase funding for machinery innovation and research (H2020, EIP etc. national programmes)
- **Soft control mechanism:**
  - Monitor progress towards voluntary targets.
- **Politically feasible? Really enough? Probably not…**

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Regulatory options for agriculture – comprehensive/systemic scope, ‘big game’

All GHG emissions related to agricultural production and activity!

AGRICULTURE

- Nitrous oxide & methane
- Land
- Land use (LULUCF)
- Buildings & machinery
- Inputs (fertilizer)

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4. Specific practice: what are the regulators doing on CO2 mitigation in agriculture?

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Regulatory options for agriculture – the ‘scattered game’ (divide & rule)

AGRICULTURE

- ► Nitrous oxide & methane
- ► Land

LULUCF

- ► Land use
- ► Buildings & machinery

ENERGY/ TRANSPORT

- ► Inputs (fertilizer)

INDUSTRIAL PROCESSES

European Commission

JRC TECHNICAL REPORTS

An economic assessment of GHG mitigation policy options for EU agriculture

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Mission impossible?

- *The study follows the Common Reporting Format (CRF) of the United Nations Framework Convention on Climate Change (UNFCCC), where the source category 'agriculture' only covers the emissions of nitrous oxide and methane. According to the CRF, emissions (and removals) of carbon dioxide (CO2) from land use, land-use change and forestry (LULUCF) activities as well as CO2 emissions related to energy consumption at farm level (e.g. in buildings and machinery use) or to the processing of inputs (e.g. mineral fertilizers) are attributed to other sectors and hence, unless specifically indicated otherwise, not considered in the report at hand.*

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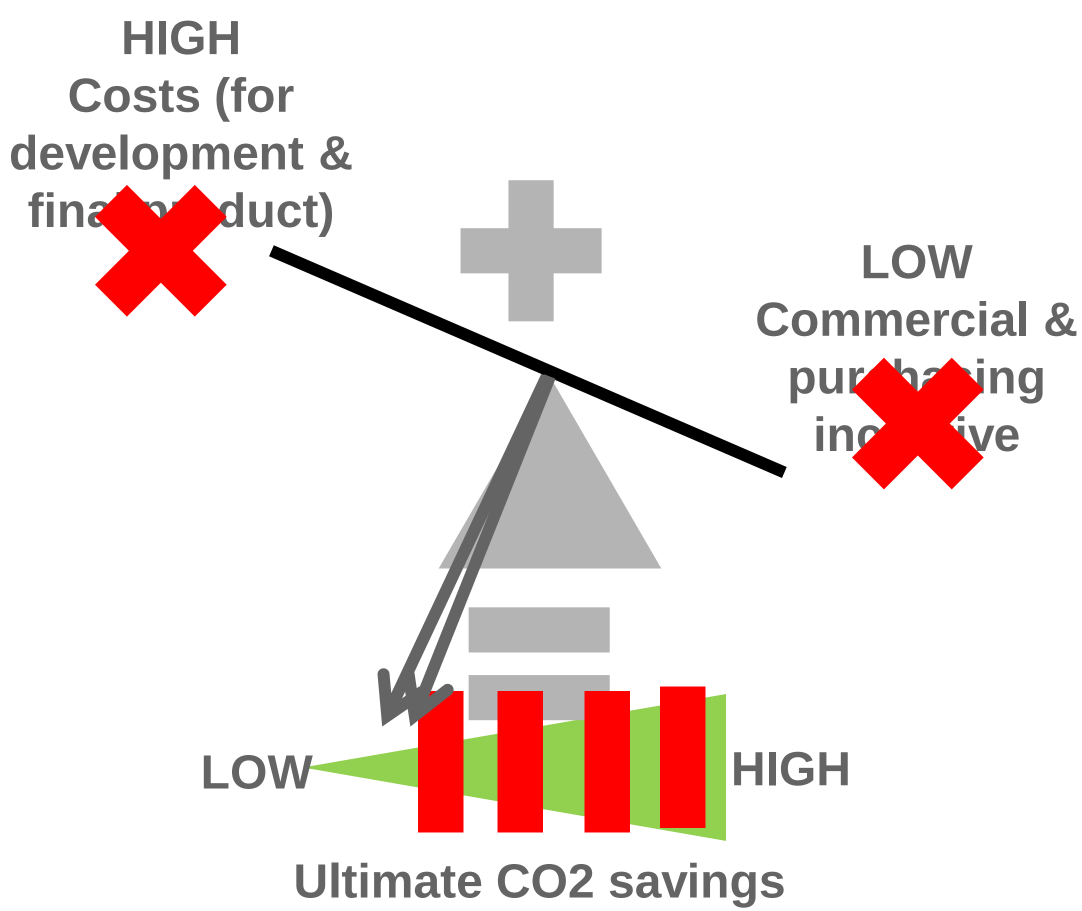
Regulatory worst case – scattered approach & loss of wider push-pull connections



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5. Our task: what can we do to get it right?

CO2 reductions in agriculture: need to follow a smart, comprehensive regulatory approach

- GHG reduction approaches in agriculture should start with a comprehensive view and work backwards from there, rather than rushing blindly to scattered regulation of specific sub-sectors/aspects (otherwise, risk of high-cost/low-impact regulation)
- Still, sub-sectors need to contribute to GHG reductions in agriculture in their own right. This is acceptable provided the overall equation makes sense and spill-over/trickle down effects are duly considered
- Following target definition, regulatory approaches should start with soft, voluntary measures before gradually moving to ‘harder’ interventions on a need-by-need basis

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Smart, comprehensive GHG reduction regulation in agriculture: practically feasible?

Yes..

- …and it's already happening (market-based dynamics) with CO_2 LCAs for food products (push from supermarket chains)
- Farming in Europe is tightly regulated and sizeable chunks of public money are attached to it (a regulator's dream scenario for exerting a strong push effect)

But…

- Virtually all ag stakeholders are strongly opposed
- Future for agriculture is a delicate, 'toxic' debate marked by ideological turf wars
- IPCC classification and regulator's (European Commission's) default way of working (organigramme) is to slice & dice the problem and follow a scattered appraoch (divide and rule)

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What can the ag machinery industry do to advocate smart, comprehensive regulation?

- **Evidence base & voluntary commitment:** provide data and targets on the future CO2 saving potential that can be reached with the help of agricultural machines
- **Underline inherent link between machine and process:**
  - Showcase essential link between ag machinery and Total Factor Productivity (TFP) in farming
  - Showcase win-win solution potential of Precision Agriculture
- **Suggest how soft (research funding) and hard (CAP) EU regulatory measures** could be used in smart, comprehensive ways to achieve GHG reductions in agriculture

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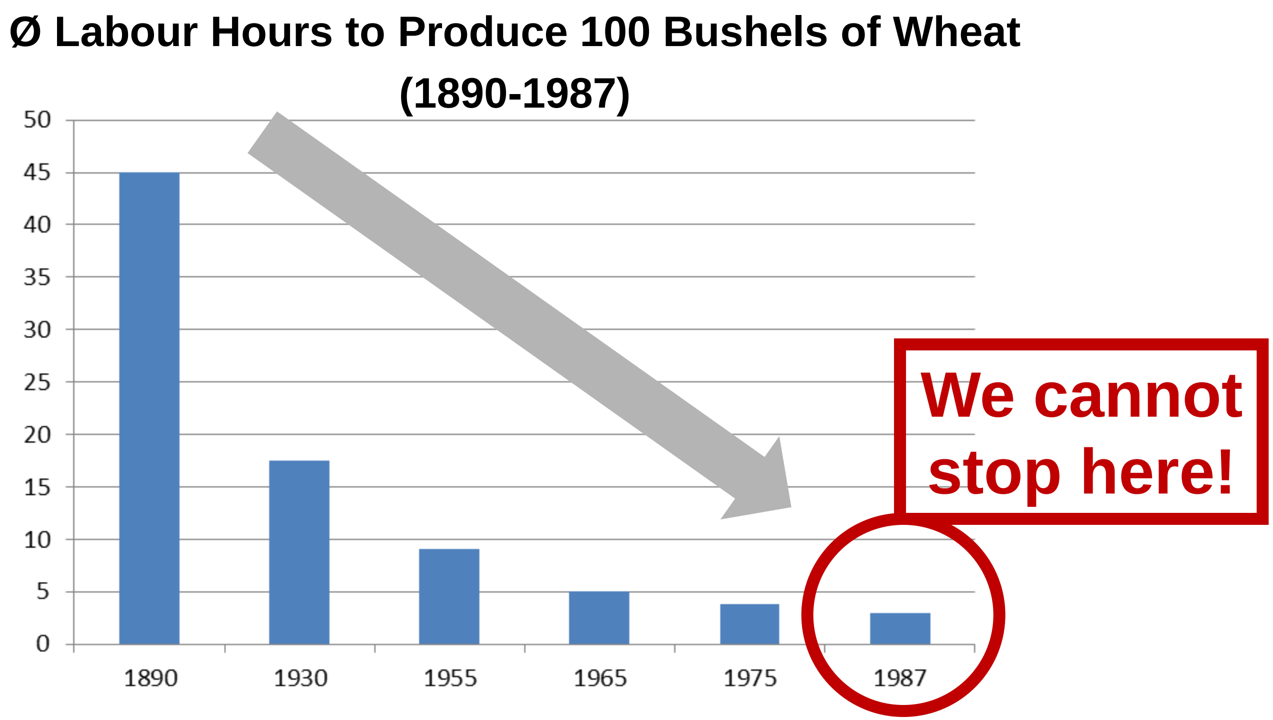
Smart regulation fundamentals: TFP growth in agriculture is driven by mechanisation

- Some of the **biggest single events improving TFP have been delivered by advances in agricultural machinery!**



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Smart regulation fundamentals: win-win solution potential of Precision Agriculture

- ✓ Higher yield potential
- ✓ Less crop damage and crop loss

Higher Productivity

Greater Sustainability

- ✓ Less quantity of inputs (fuel, water, fertiliser etc.)
- ✓ Higher use efficiency
- ✓ More environmental protection

.

Economic & other benefits for the farmer

- ✓ Greater application speed
- ✓ Reduced working hours
- ✓ Lower production costs

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Smart regulation for climate-smart agriculture – how could it work?

- Start voluntary CO_2 monitoring systems (later on, impose mandatory targets and ETS???) at farm level (data, data, data!)
- Focus future CAP post-2020 on enhancing productivity, i.e. efficiency of production (including CO_2 efficiency)
  - Consider inclusion of hard pull effect measures under the CAP, such as a productivity bonus (modified greening system) or tools to facilitate access to and uptake of Precision Farming equipment (based on greening equivalence schemes).
- The practical obstacles are high, but we need to make sure regulators understand and see mobile machines for what they could be in the next years: some the best available tools to make further progress on productivity & sustainability in agriculture, including CO_2 reductions!

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Summary

1. Smart regulation definitions & concepts exist
2. BUT: they are rarely, if ever, applied 1:1 in practice (for various reasons – politics is not a science!)
3. Smart, systemic regulatory approaches to reduce CO_2 in agriculture could be developed – and hard regulatory instruments are at hand that could enforce them (CAP etc.)
4. BUT: regulators (and stakeholders) are opposed & have followed a scattered approach (small scope, hard measures, every-bit-counts-never-mind-the-rest) which bears inherent risks of high-cost/low-impact regulation for mobile machines
5. We need to push back & re-iterate the need to see the broader picture and make the case for smart, systemic regulatory approaches (starting maybe with soft measures) to maximize CO_2 mitigation contribution of mobile machines in agriculture

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Thank you!

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Technische Universität Braunschweig

Institut für mobile Maschinen und Nutzfahrzeuge

Efficiency of Mobile Machines and their Applications

A Contribution to the Reduction of GHG

Symposium 10th / 11th March 2015 in Braunschweig

Programme

Wednesday, 11th March 2015
Venue: Stadthalle Braunschweig – Congress Hall

Session I: Background to the topic (Ludger Frerichs)

08:30 Opening remarks
Prof. Ludger Frerichs (TU Braunschweig)

08:45 The global context of GHG-emissions and climate change
Dr. Benjamin Leon Bodirsky (Potsdam Institute for Climate Impact Research)

09:15 Approach to reducing GHG in agriculture
Dr. Annette Freibauer (Thünen Institute)

09:45 Energy- and carbon management in the building sector
Dr. Peter Krammer (STRABAG)

10:15 Coffee break

Session II: Achievements and potentials (Marcus Geimer)

10:45 Potential improvements in efficiency - viewpoint of construction and road building machinery manufacturers
Dr. Wolfgang Burget (Liebherr-EMtec GmbH),
Dr. Martin Göbel (Wirtgen GmbH)

11:30 The scope of efficiency improvement in the agricultural machinery industry
Dr. Eberhard Nacke (CLAAS KGaA mbH)

11:45 Efficiency potentials of ICT in agriculture
Dipl.-Wirt.-Inf. (FH) Jan Horstmann
(Maschinenfabrik Bernard Krone GmbH)

12:15 Lunch break

Session III: Achievements and potentials (August Altherr)

13:15 Sustainable energy storages for mobile machines
Prof. Marcus Geimer (Karlsruhe Inst. of Technology)

13:45 What prevents us from using more efficient technology?
Prof. Reiner Brunsch (ATB Potsdam)

14:15 Coffee break

Session IV: The smart way forward (Wolfgang Burget)

14:30 CO_2-quantification of agricultural machinery
M.Sc. Beate Fleck (CLAAS KGaA mbH),
M.Sc. Steffen Hanke (TU Braunschweig)

15:00 CO_2-quantification of mobile machines on construction sites
Dipl.-Ing. Isabelle Ays (Karlsruhe Inst. of Technology)

15:30 We need smart regulation for mobile machines
Dr. Ulrich Adam (CEMA Brussels)

16:00 Discussion
Prof. Ludger Frerichs (TU Braunschweig)

16:30 Coffee to go

The Success of Efficiency

	Effective	Ineffective
Efficient	++	-
Inefficient	o	--

Qualified Efficiency

Efficiency

Output/Input oriented

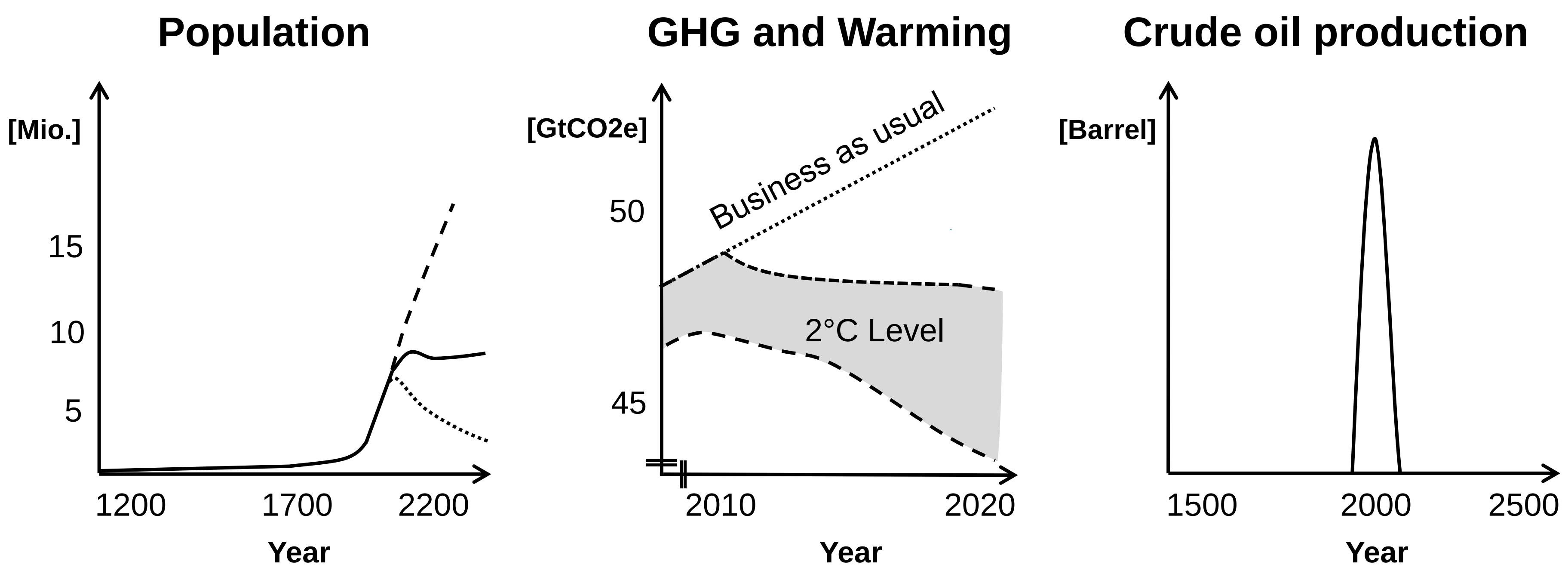
Effectivity

Output oriented
(Quality, …)

Qualified Efficiency

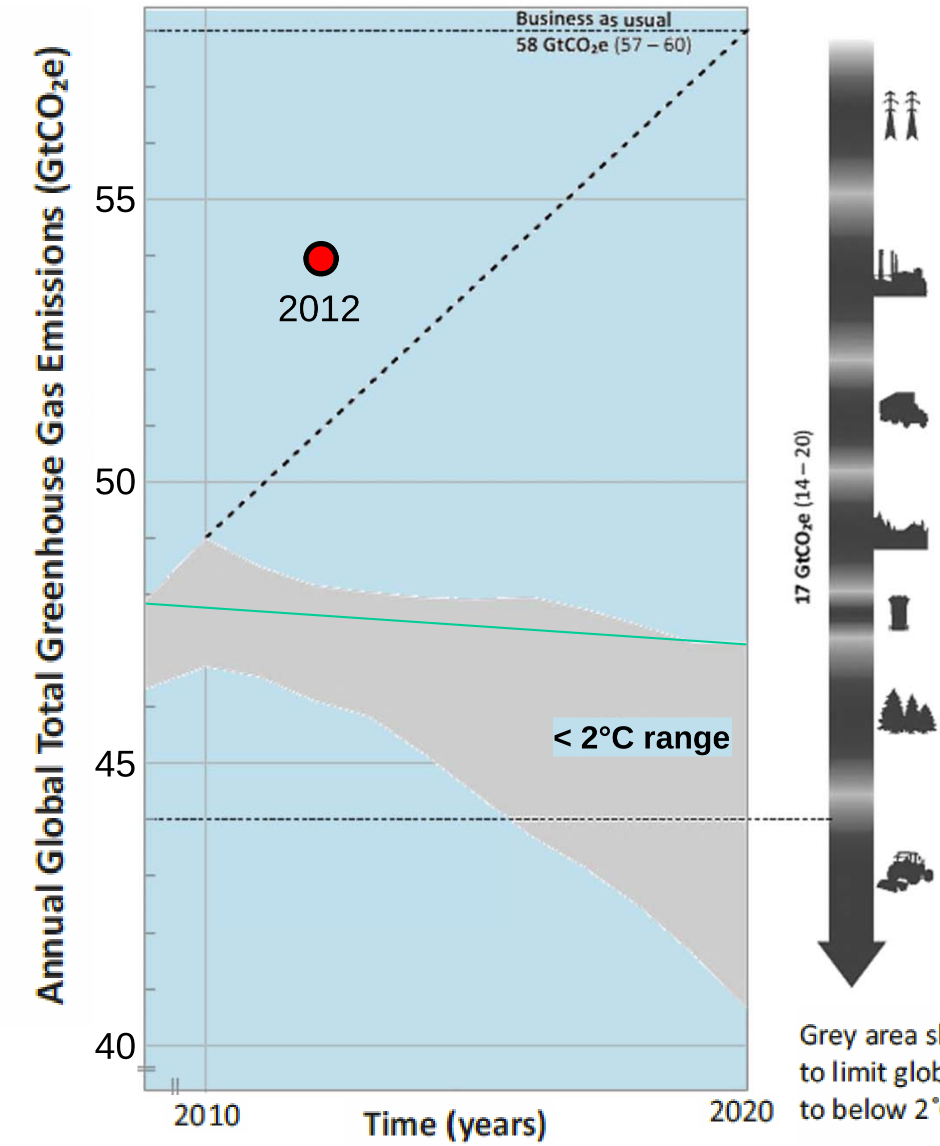
Relation of result and applied means taking into account output quality

Where to Utilize Efficiency Profit – Objectives



Improved Productivity | **Less Emissions** | **Less Resources**

Global GHG Emission and How to Bridge the Gap



Grey area shows likely range (>66%) to limit global temperature increase to below 2˚C during 21st century

How to bridge the gap?

Power sector
2.2 - 3.9 Gt CO2e

Industry
1.5 - 4.6 Gt CO2e

Transport
1.7 - 2.5 Gt CO2e

Buildings
1.4 - 2.9 Gt CO2e

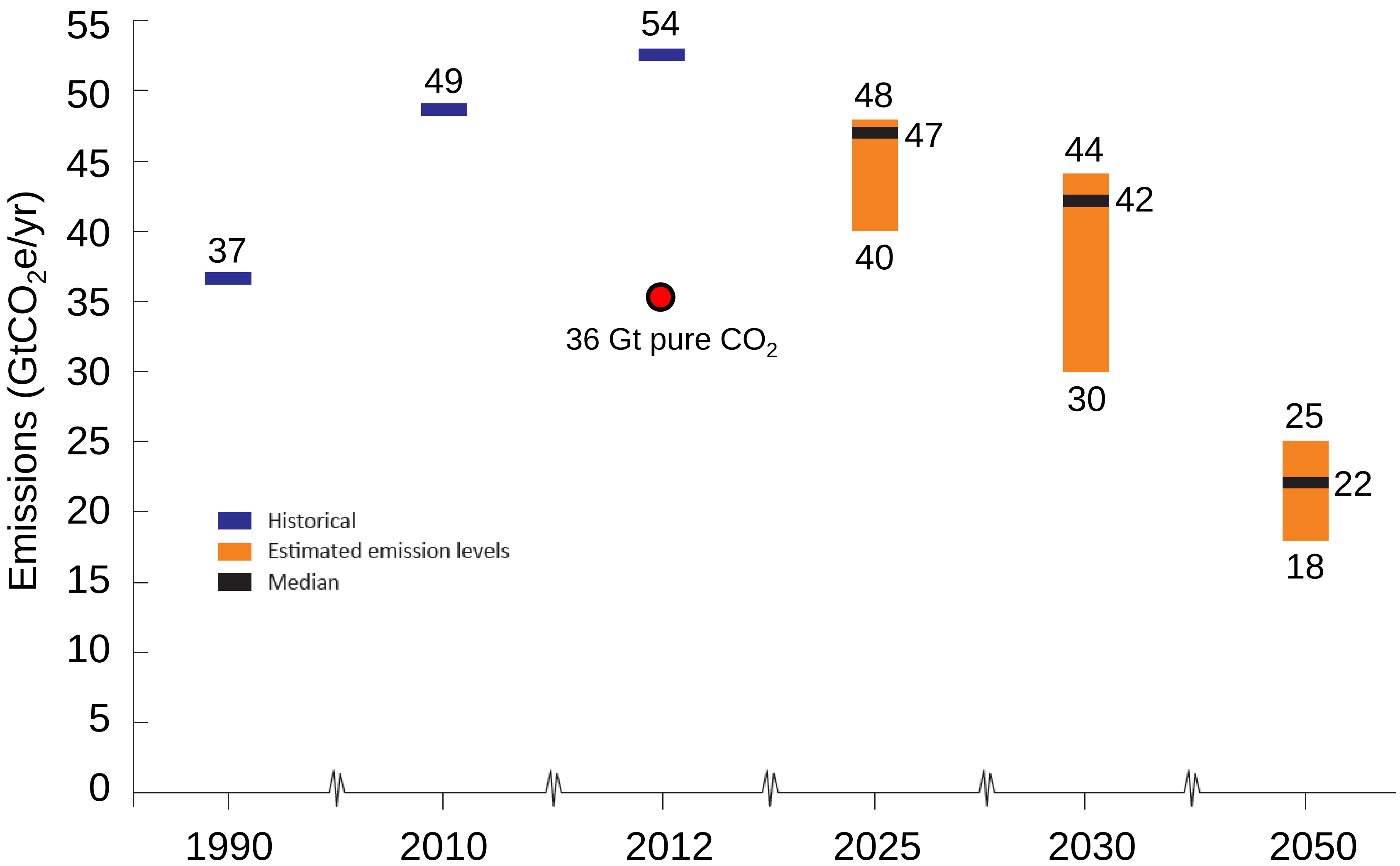
Waste
about 0.8 Gt CO2e

Forestry
1.3 - 4.2 Gt CO2e

Agriculture
1.1 - 4.3 Gt CO_2e

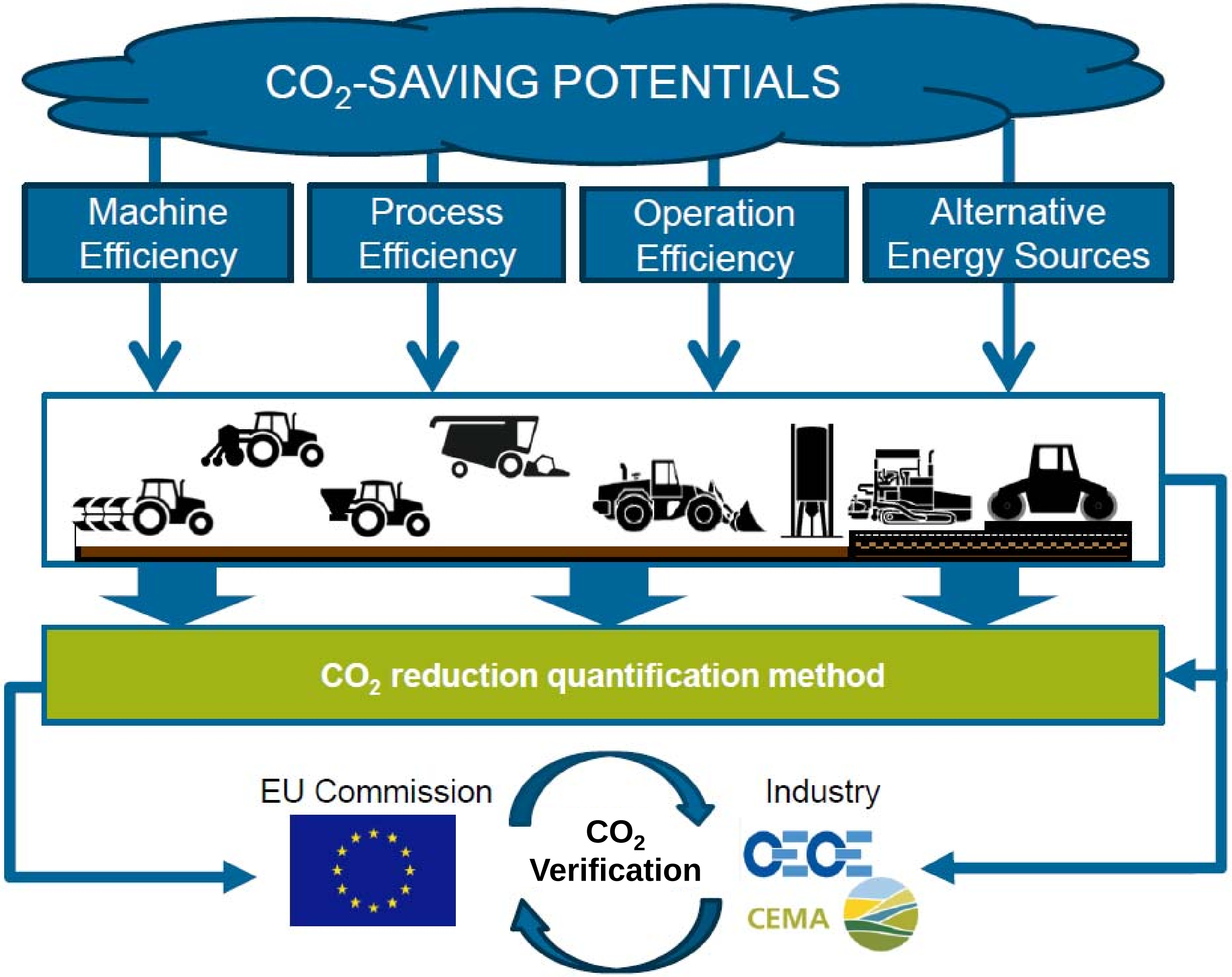
[UNEP 2012]

Emission Levels Consistent with the 2°C Target in 21st Century

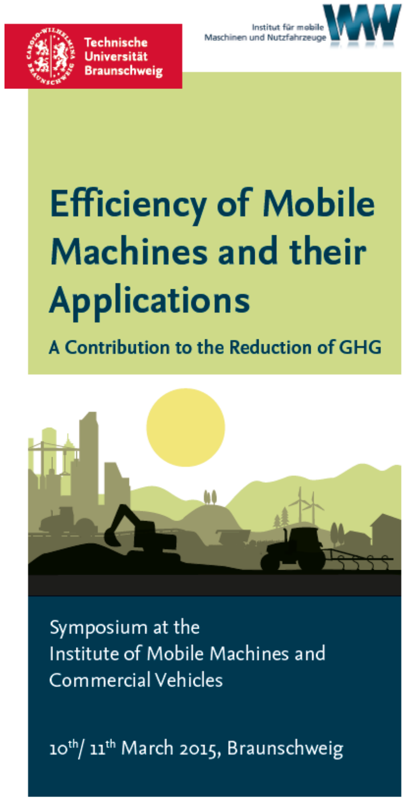


[UNEP 2014]

Basically we know what‘s to do!



It was a great pleasure



Presentations:
www.tu-braunschweig.de/imn/emma

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- **all Participants**
- **all Speakers**
- **the Programme Committee**
- **the IMN Staff**
- **ITS Niedersachen**
- **all Sponsors for their kind support**

CLAAS LIEBHERR
JOHN DEERE Wirtgen

Bon voyage!